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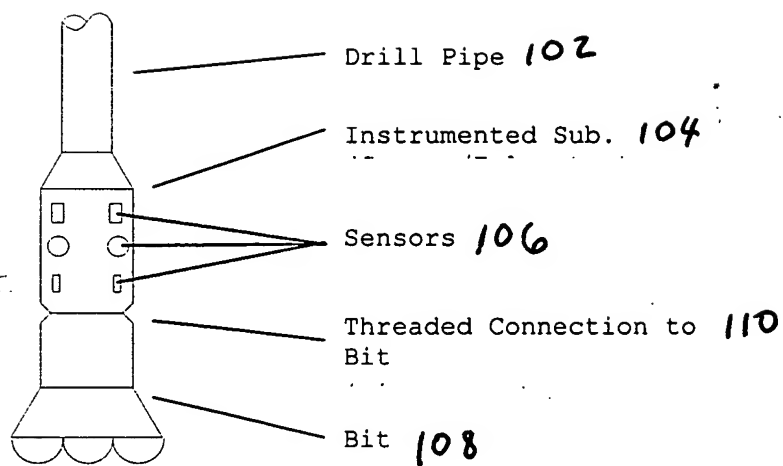


Figure 1. Sensor Placement Relative To Bit

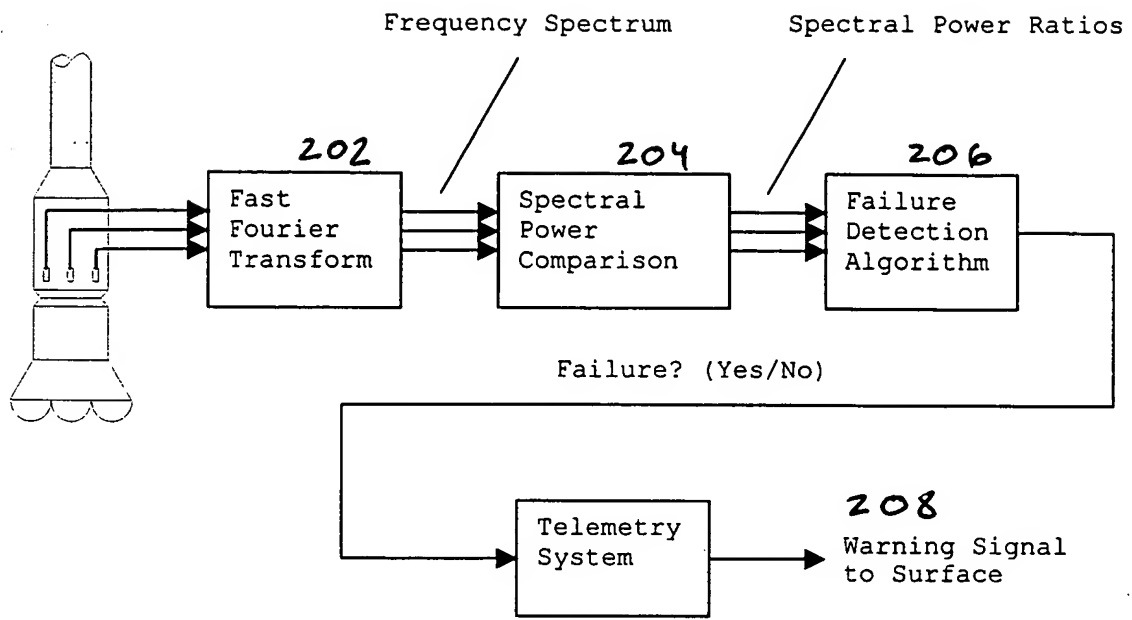
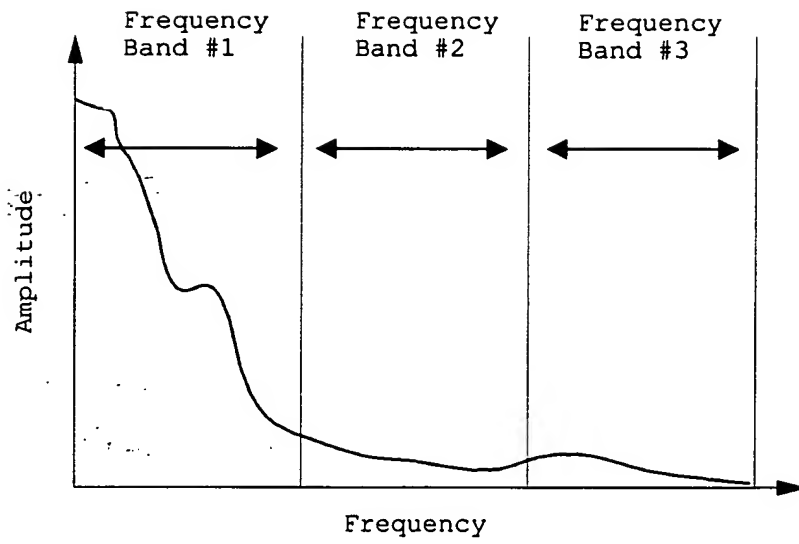


Figure 2



Figur 3. Frequency Band Arrangem nt

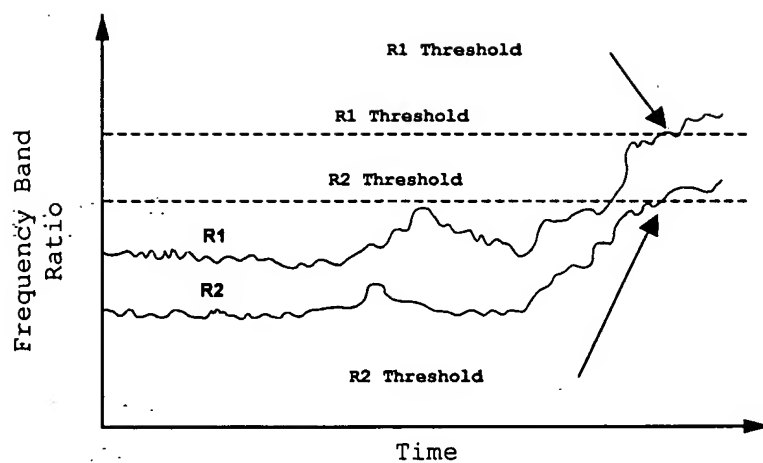
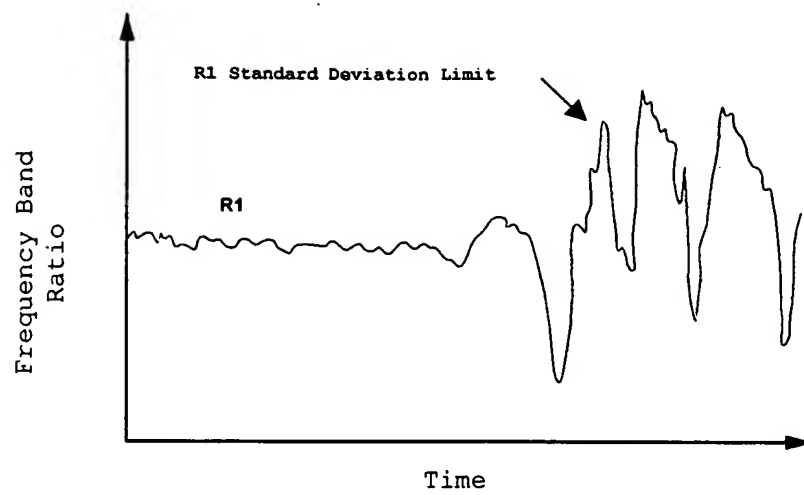


Figure 4. Threshold Failure Detection



**Figure 5 Statistical Failure Detection**

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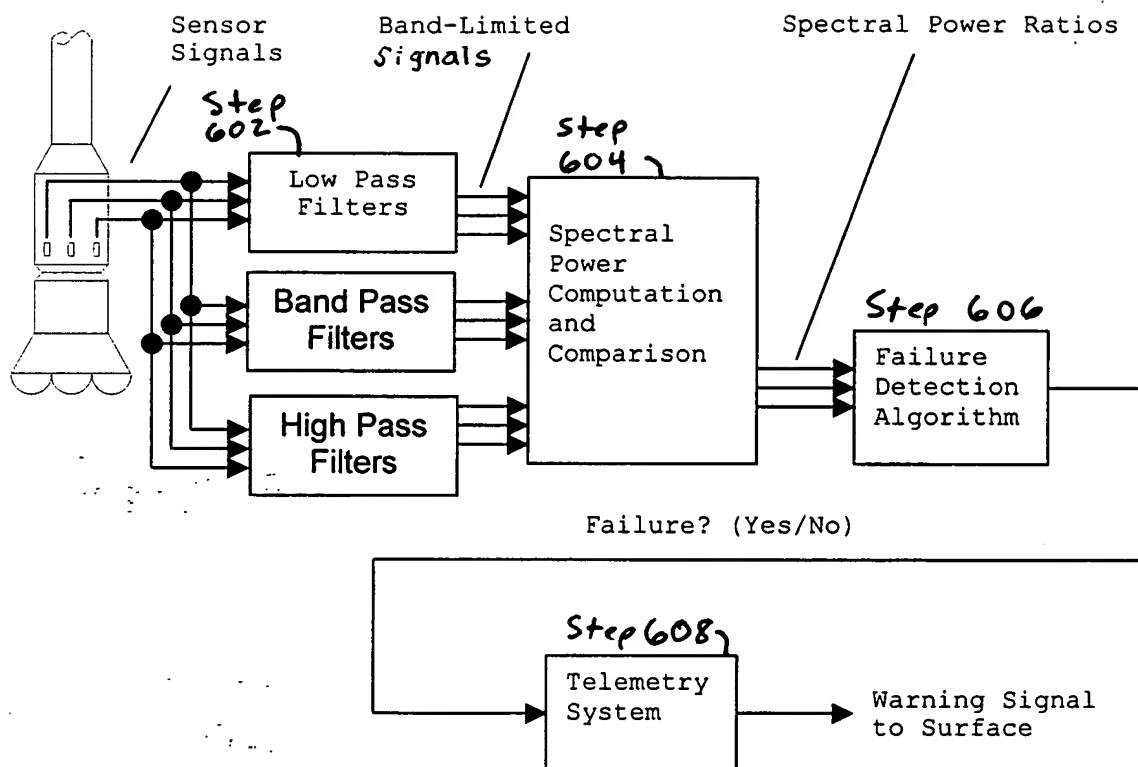


Figure 6 SPRA Method Using Analog Filters for Spectral Power Separation

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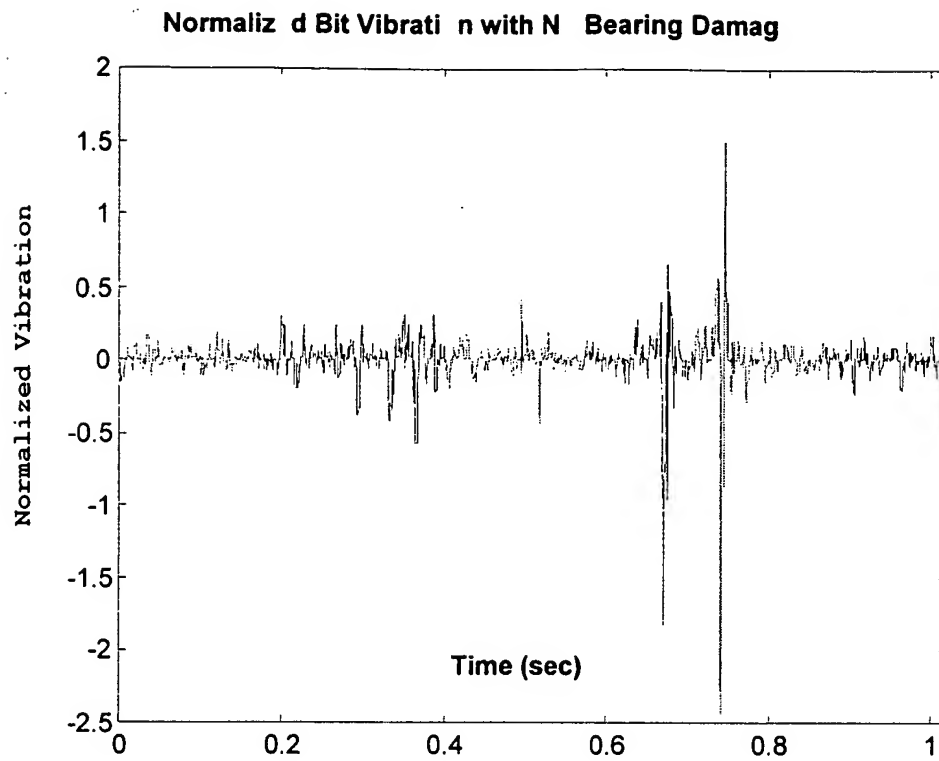


Figure 7.

Discrete FFT of Vibration Data with No Bearing Damage

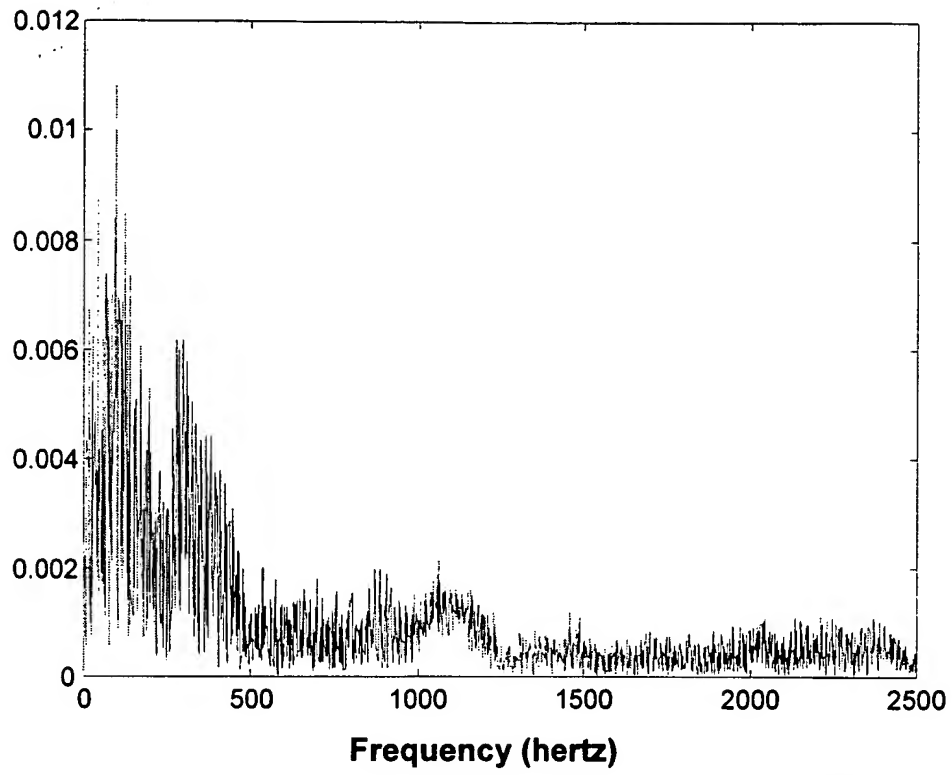


Figure 8.

FOOTNOTES



# Spectral Power Analysis Bearing with N image

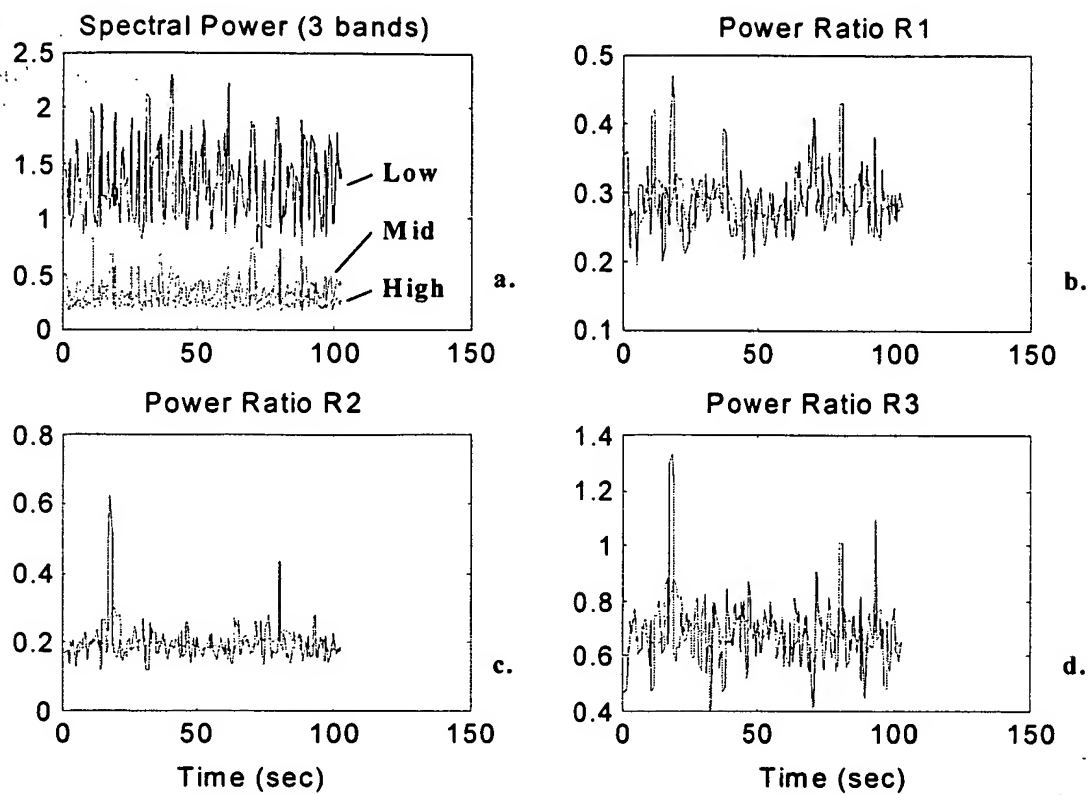


Figure 9.

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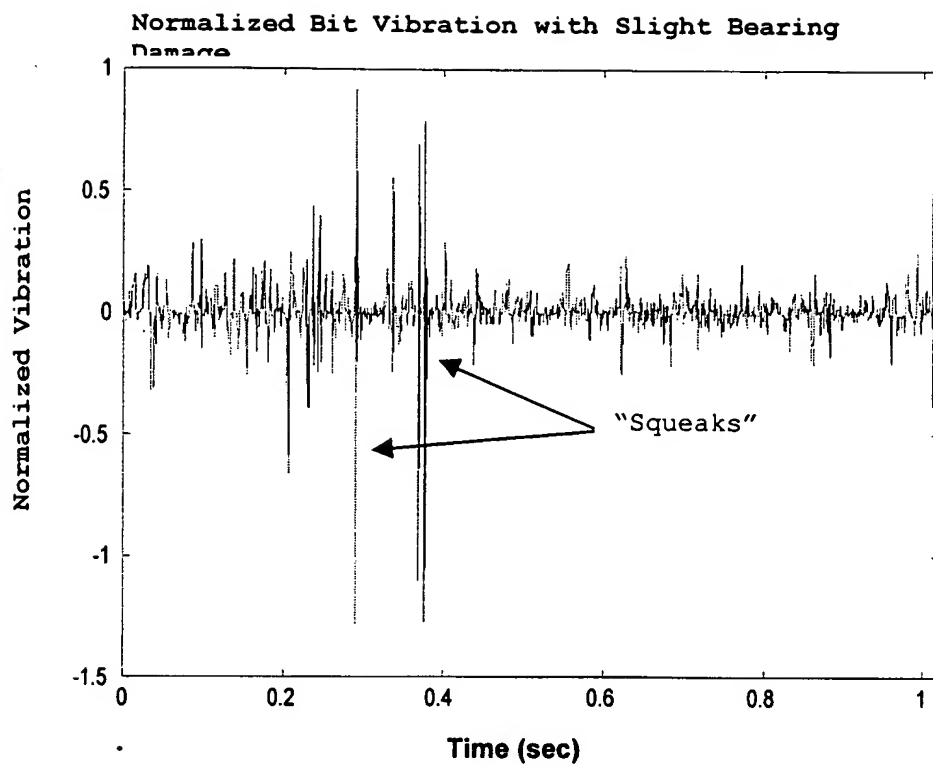


Figure 10.

Discrete FFT of Vibration Data with Initial Bearing Damage

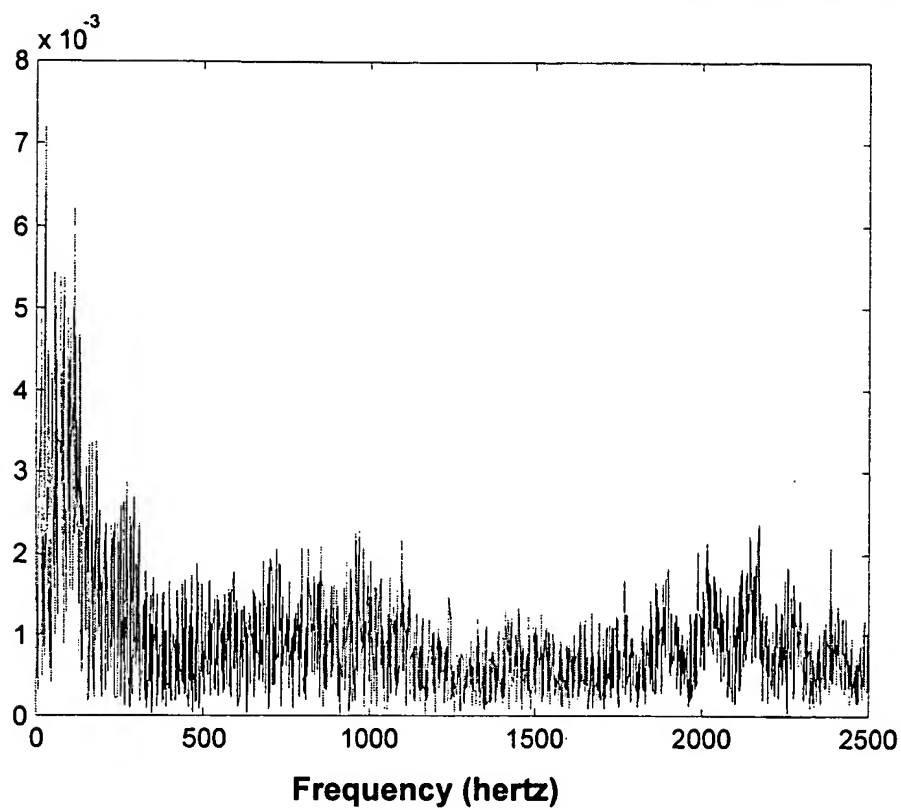


Figure 11.

# Spectral Power Analysis for Slightly Damaged Bearing

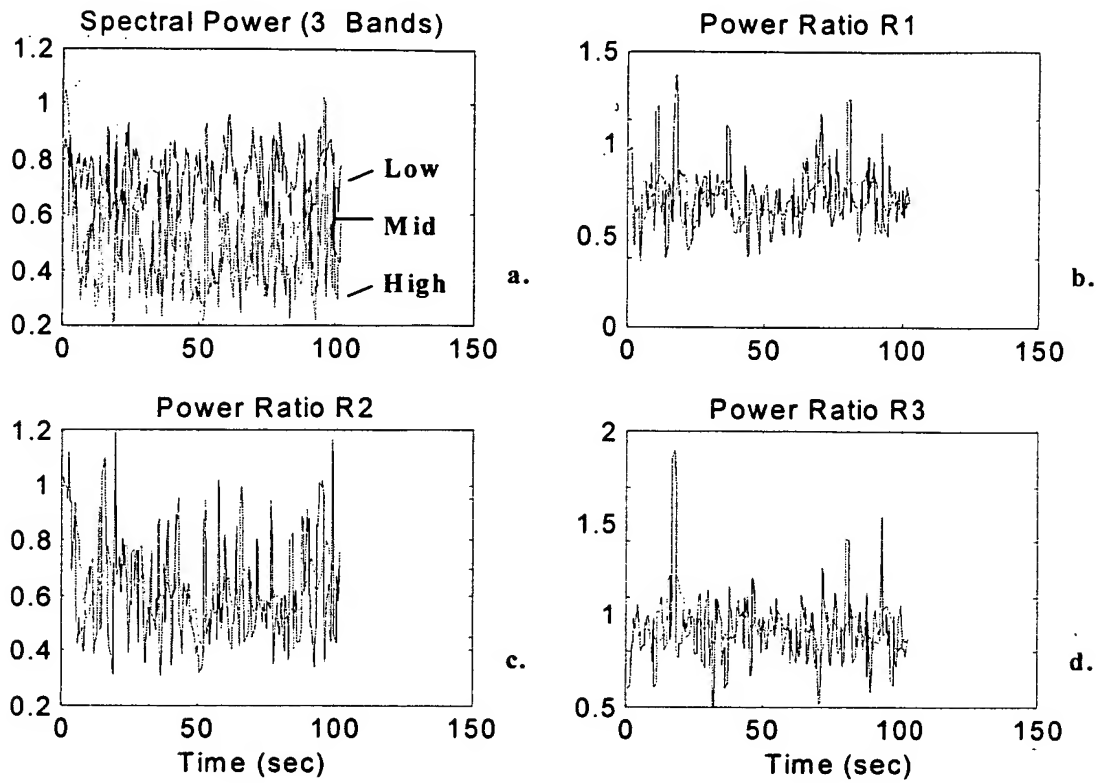


Figure 12.

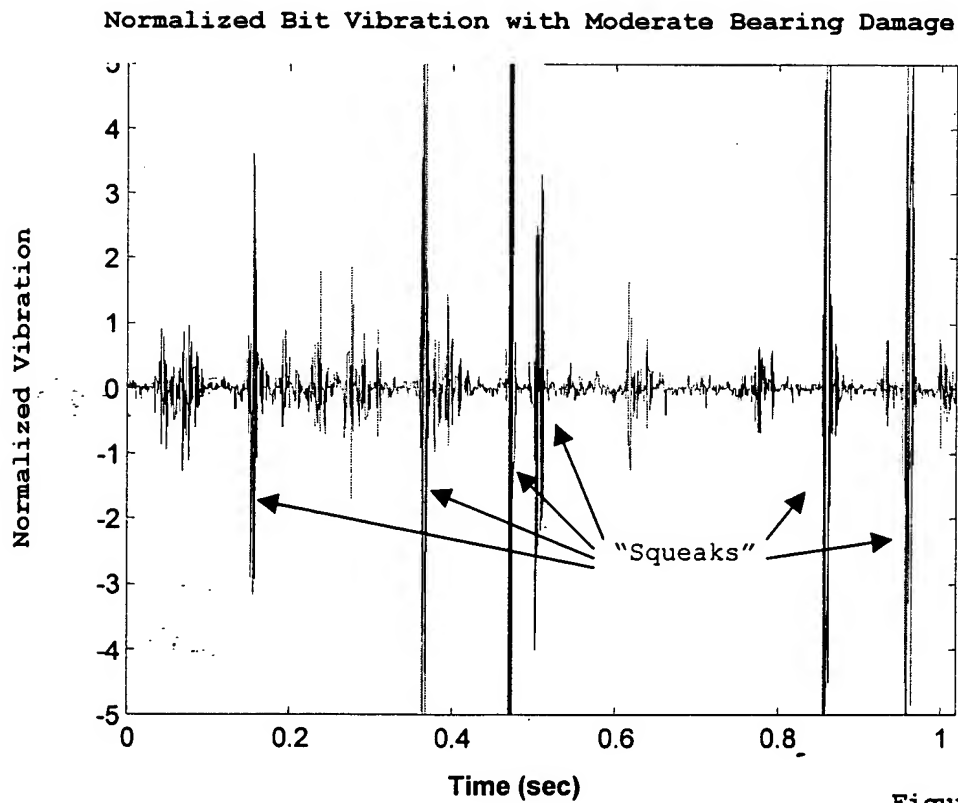


Figure 13.

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Discrete FFT of Vibration Data for Moderate Bearing Damage

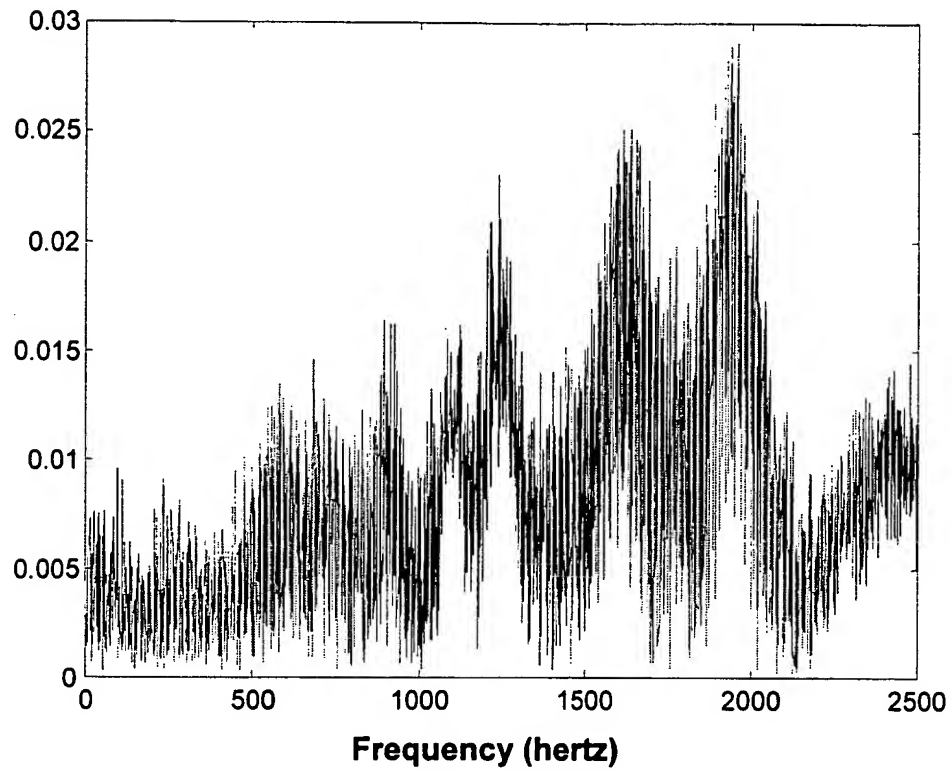


Figure 14.

10036105-101701

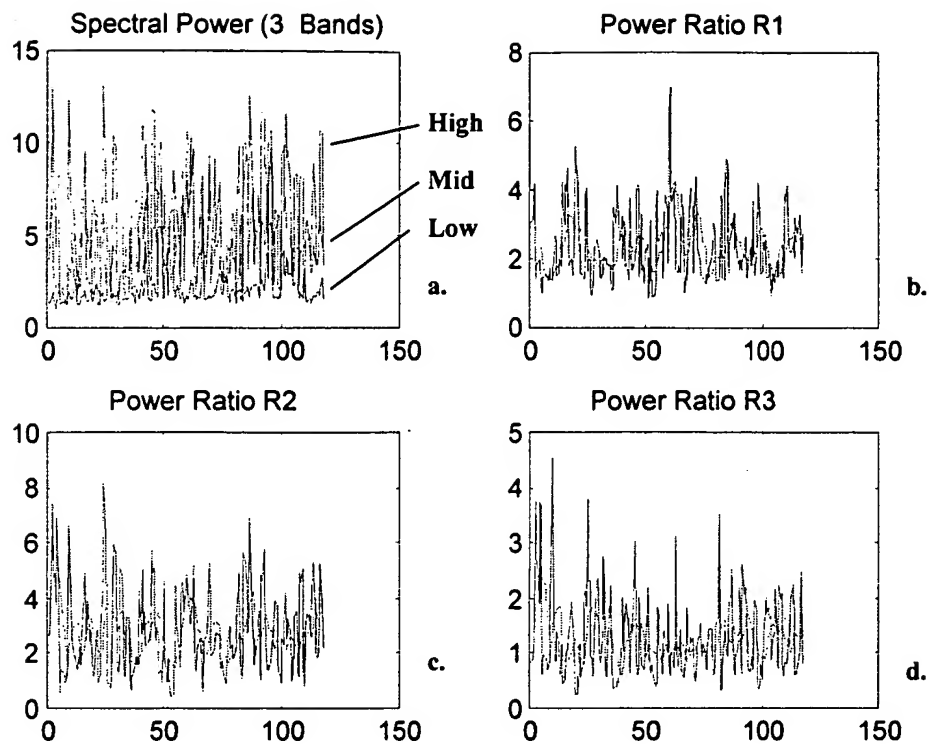
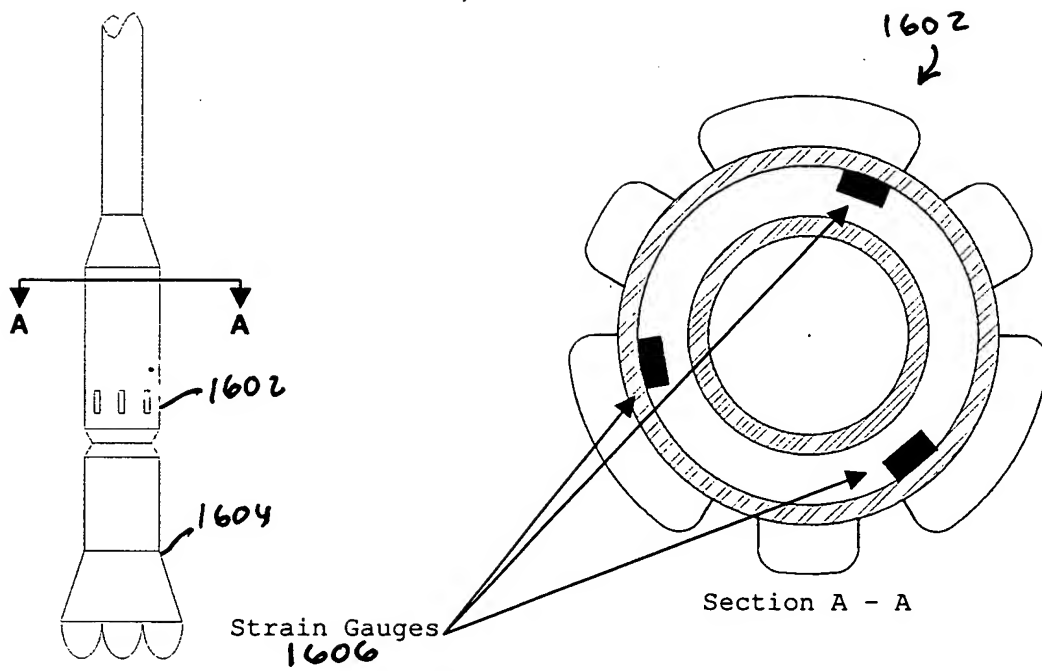
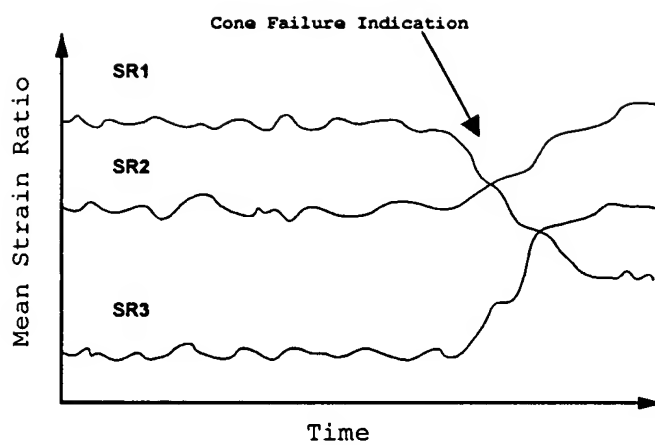


Figure 15.



**Figure 16. Strain Gauge Placement In Sensor Housing**



**Figure 17. Failure Indication (MSRA Method)**



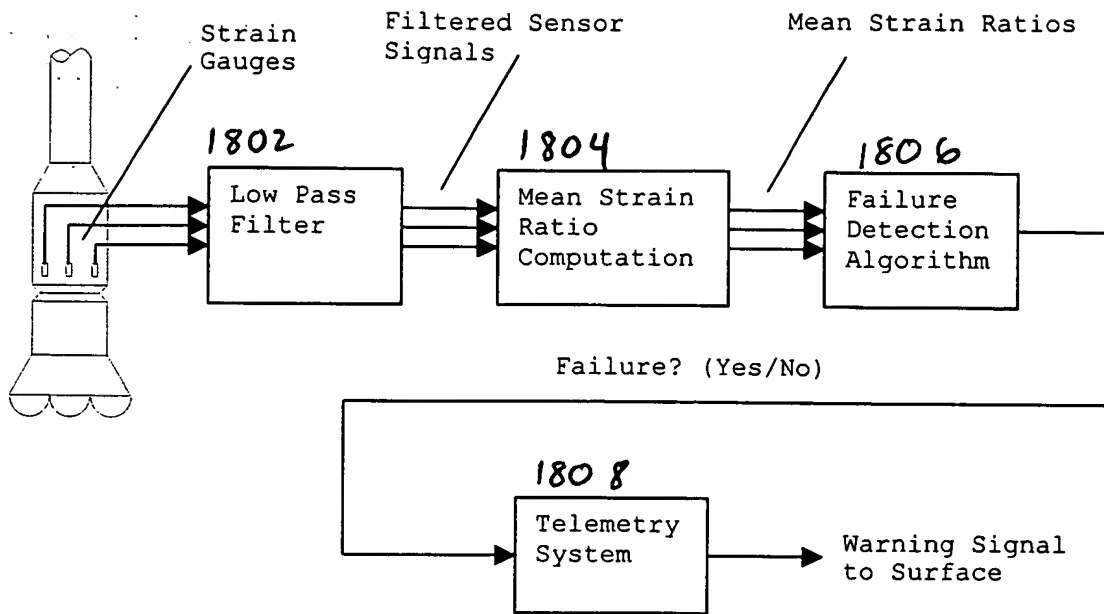


Figure 18. Schematic of MSRA Failure Detection Scheme

Strain Gaug for No Bearing Damage

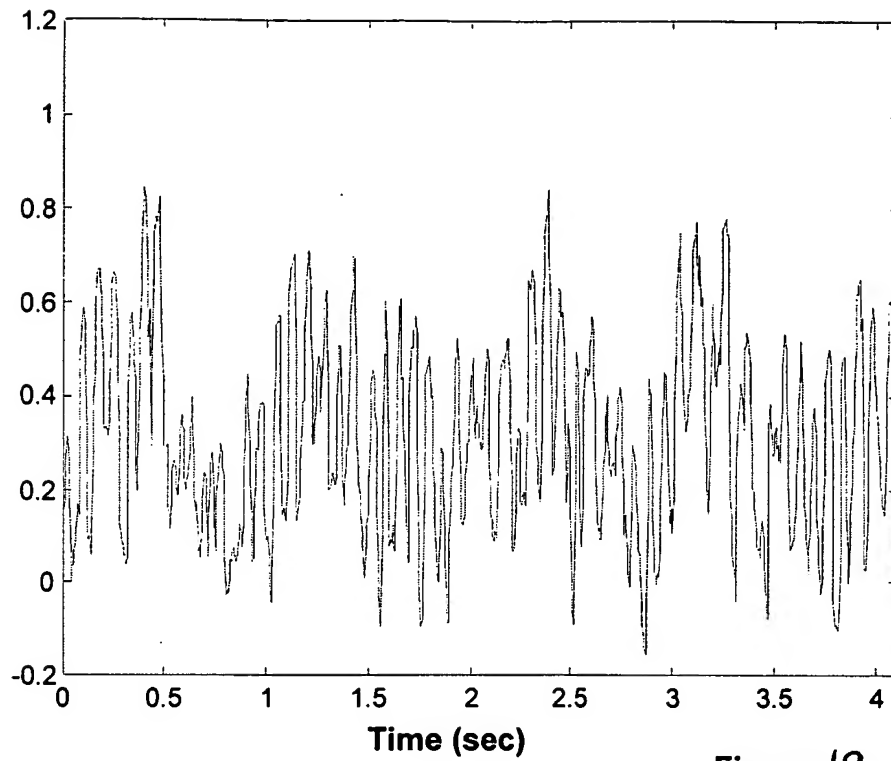


Figure 19

Discrete FFT of Strain Gauge Signal for No Bearing Damage

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# Discrete FFT of Strain Gauge Signal for No Bearing Damage

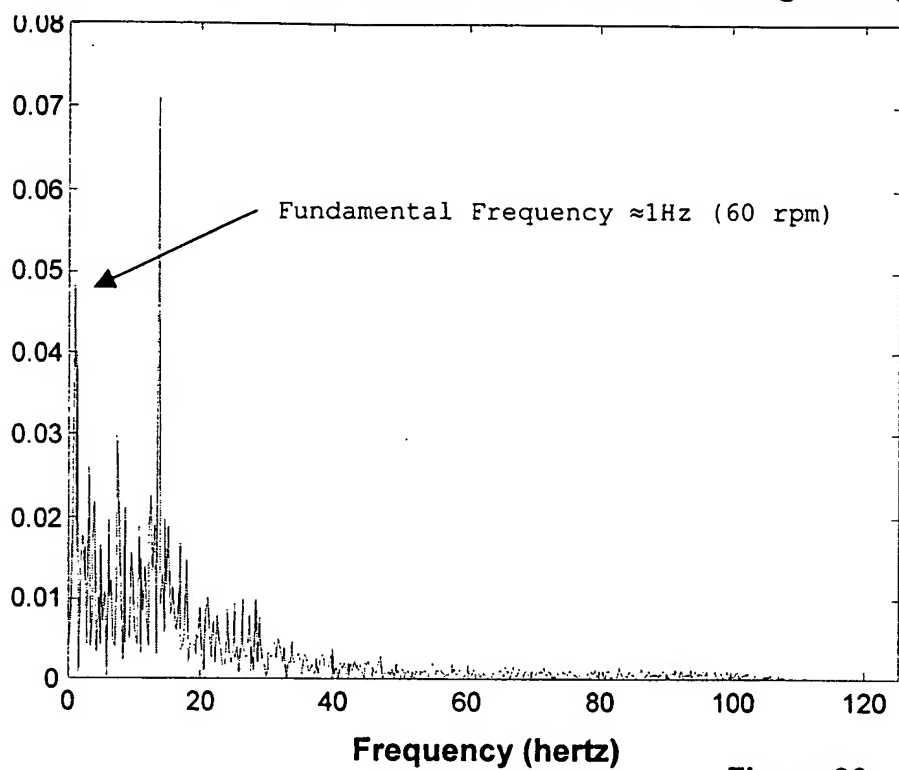


Figure 20.

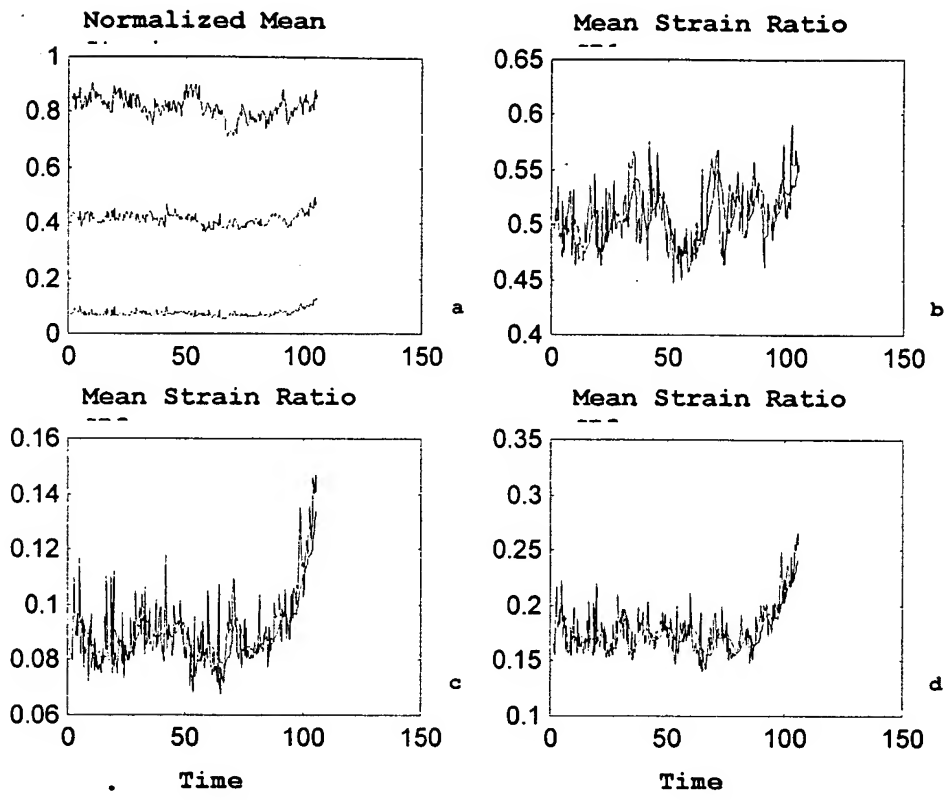


Figure 21.

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Strain Aug Signal when Bearing Lightly Damaged

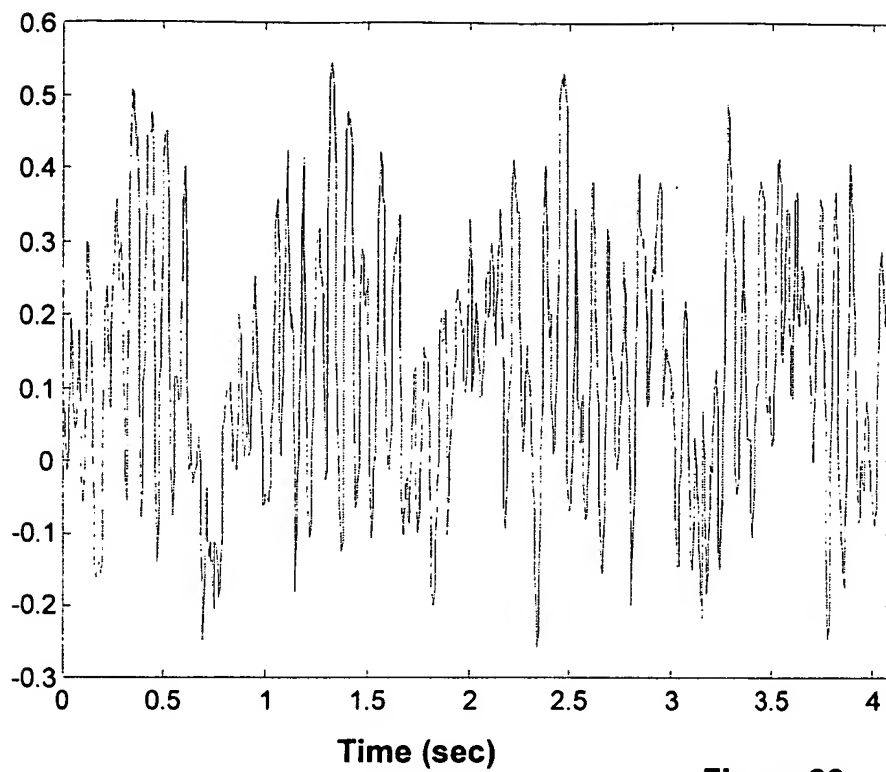


Figure 22.

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Discret FFT of Strain Gaug Signal for Light Bearing Damage

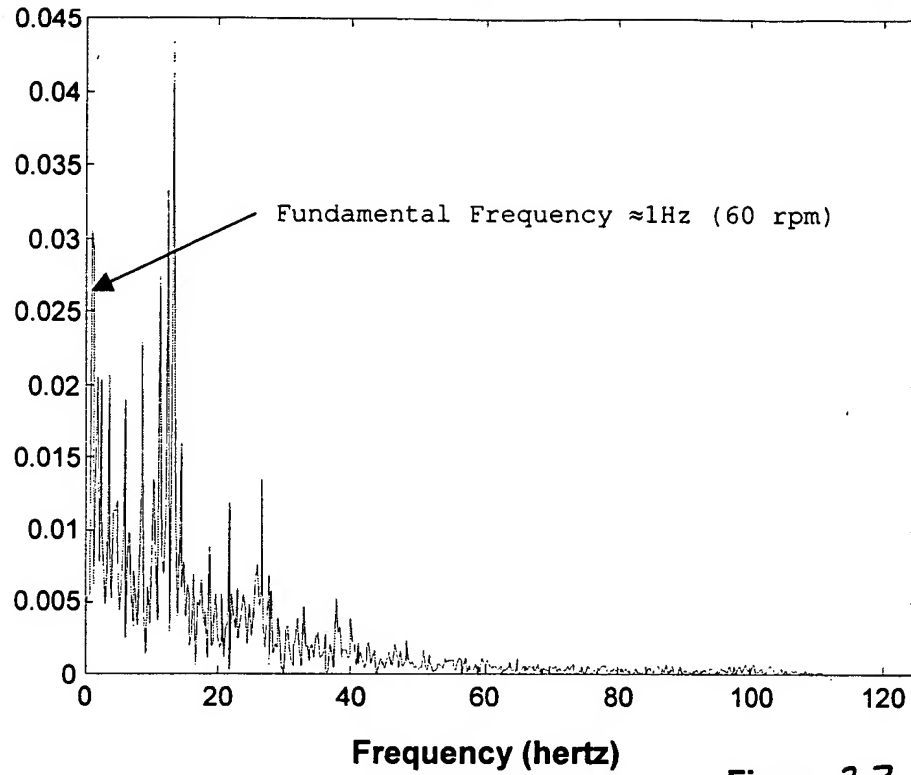


Figure 23

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# Mean in Analysis for Bearing with L Damage

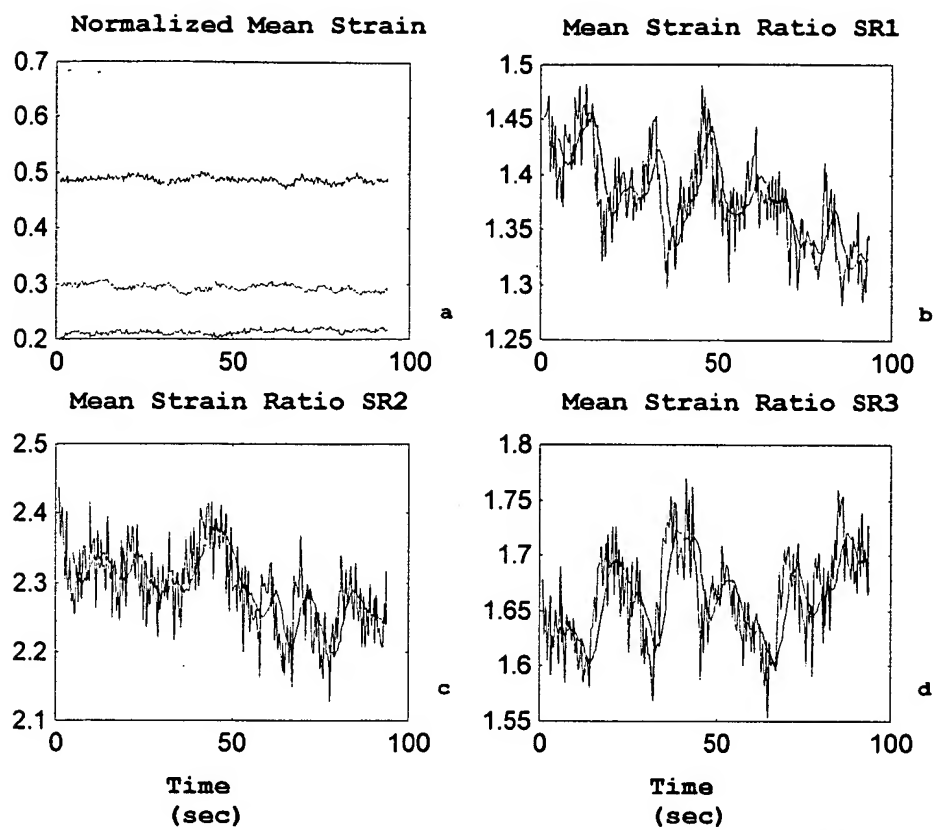


Figure 24

10036105-101701

Strain Gauge Signal when Bearing Moderately Damaged

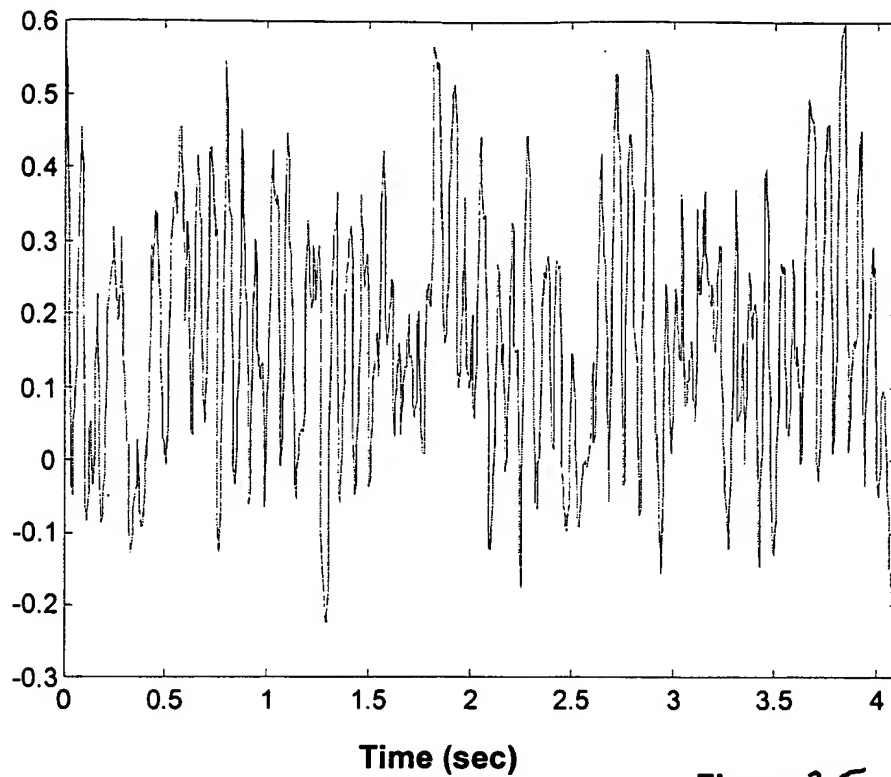


Figure 25

Discrete FFT of Strain Gauge Signal for Moderate Bearing Damage

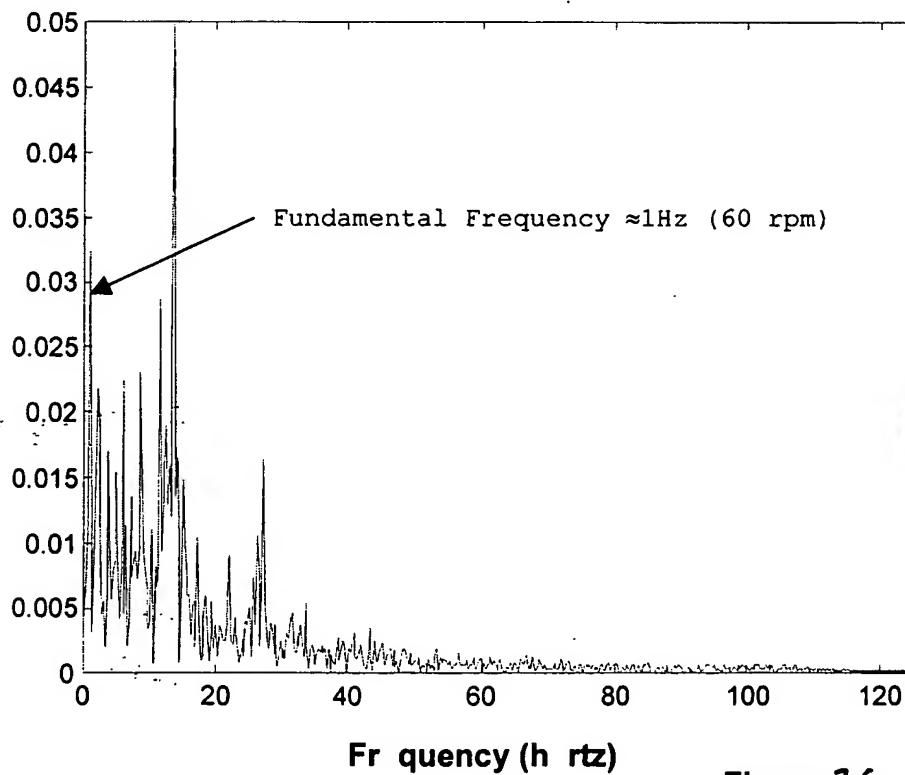


Figure 26

10036105-101701



# Mean Strain Analysis for Bearing with Moderate Damage

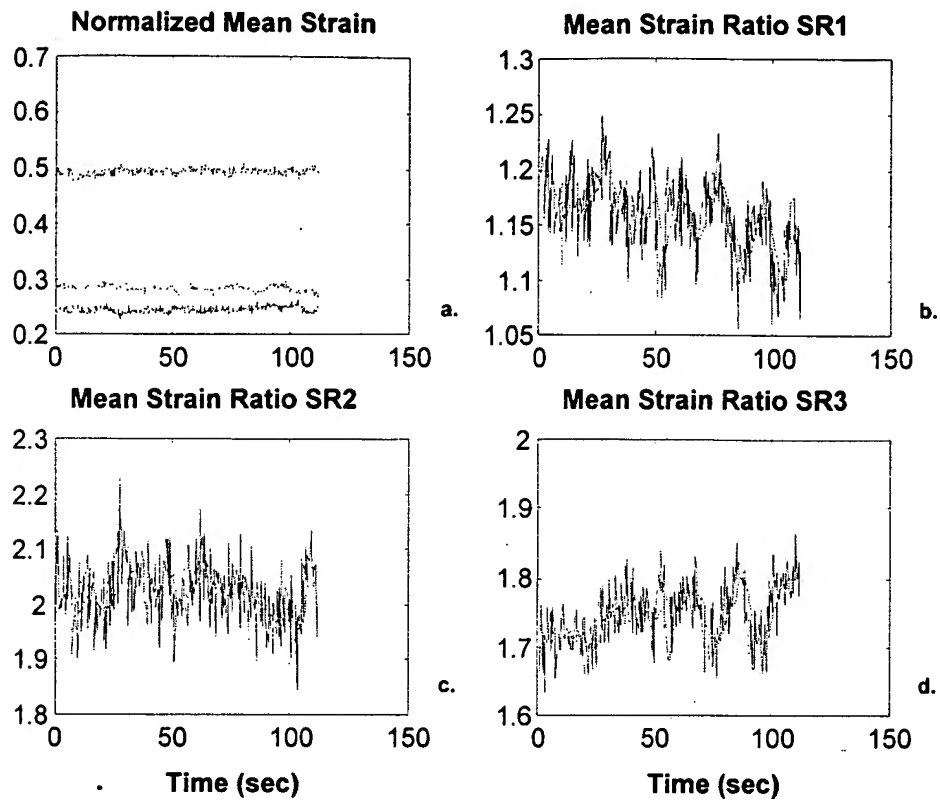


Figure 27

## Strain Gauge Signal with Bearing In Early Failure

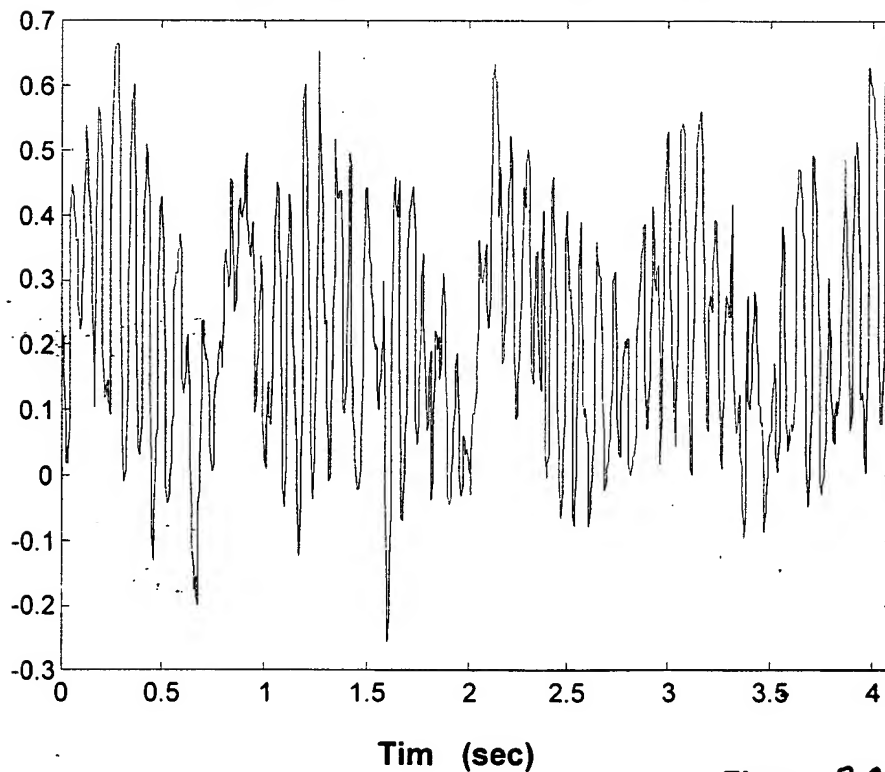


Figure 28

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Discrete T of Strain Gaug Signal for B a In Early Failur

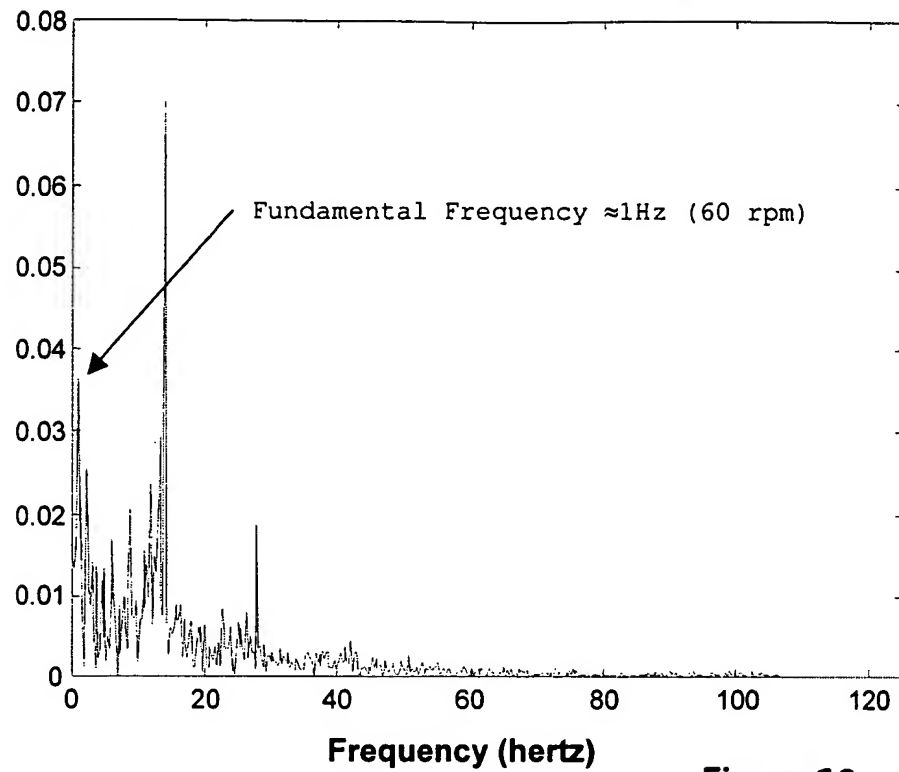


Figure 29

10036105-101701

# Mean Strain Analysis for Bearing in Early Failure

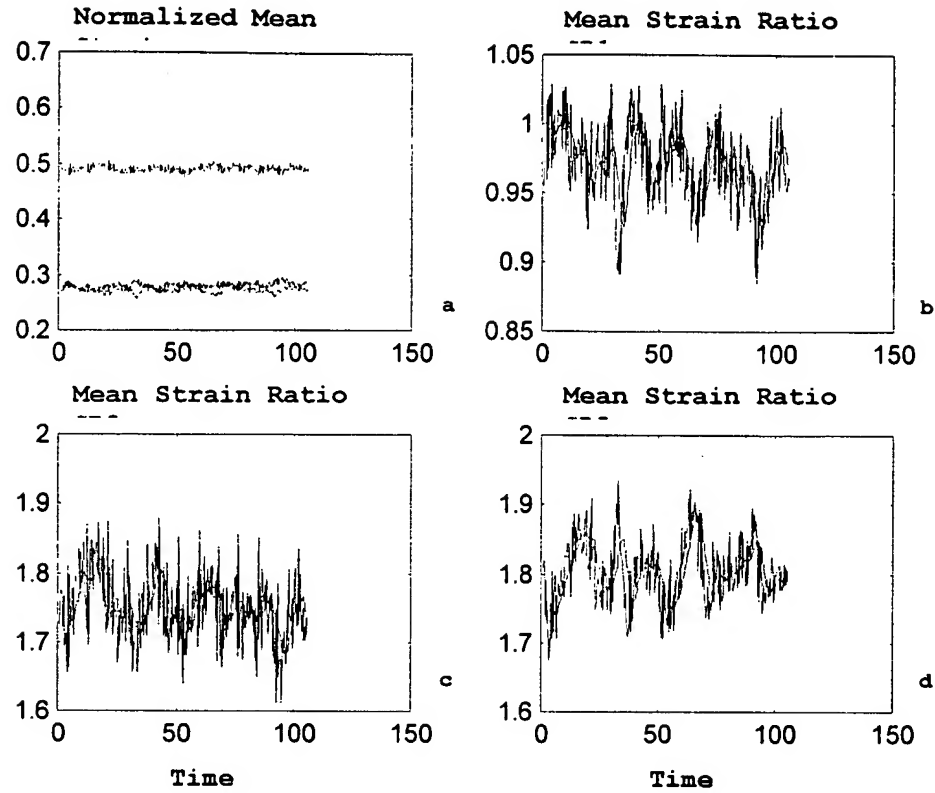


Figure 30.

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# Mean Strain Analysis for Shifting Load Condition

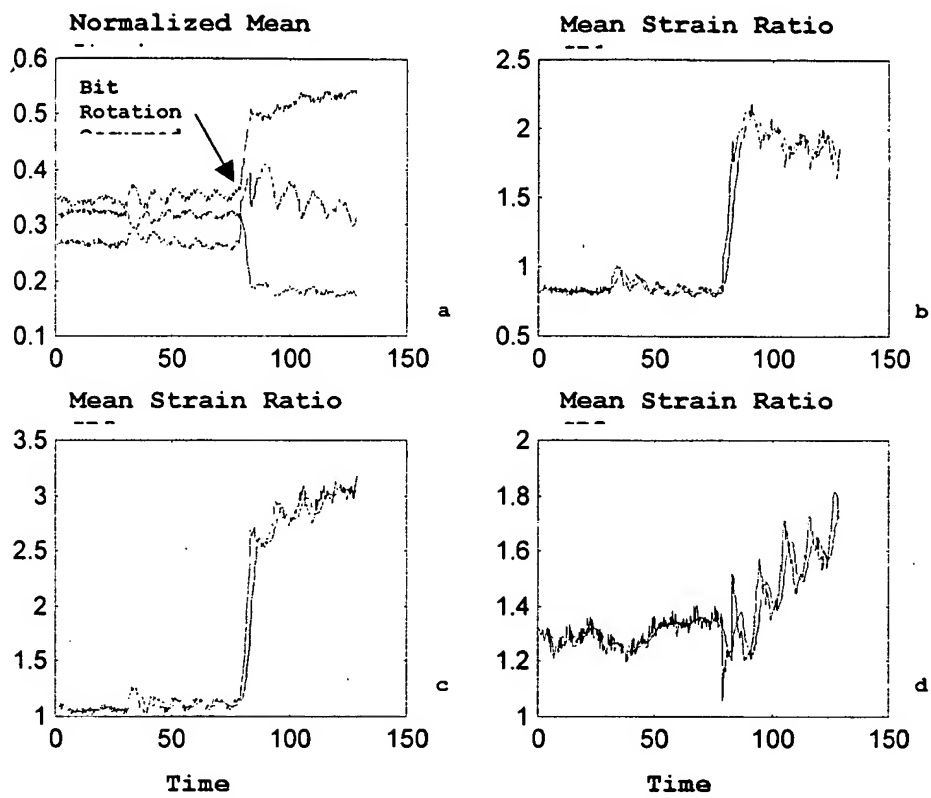


Figure 31.

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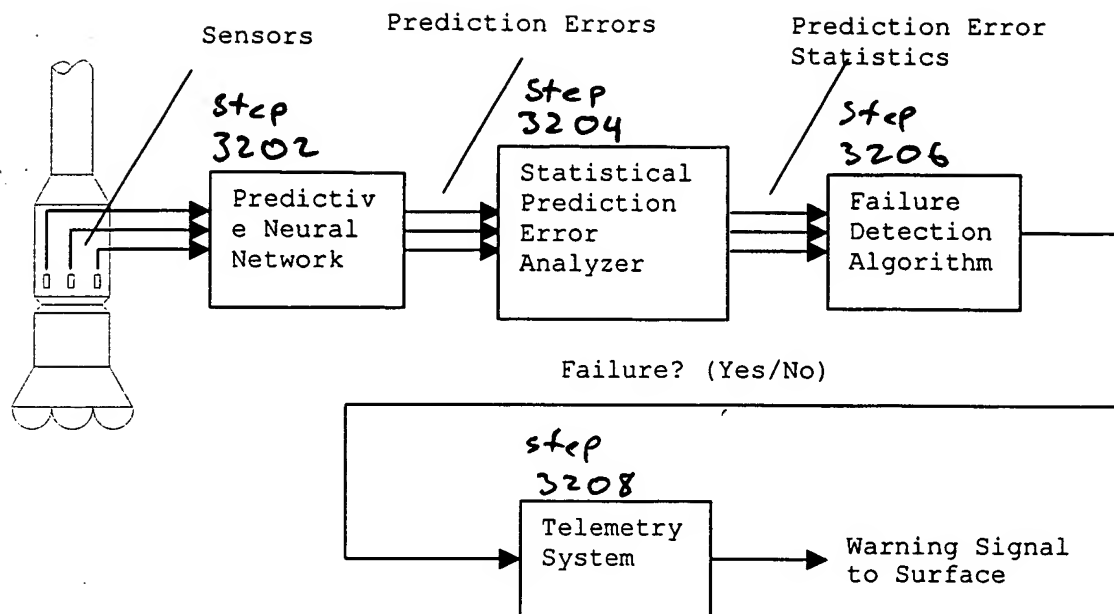


Figure 32 Schematic of ANNPA Bearing Failure Detection Scheme

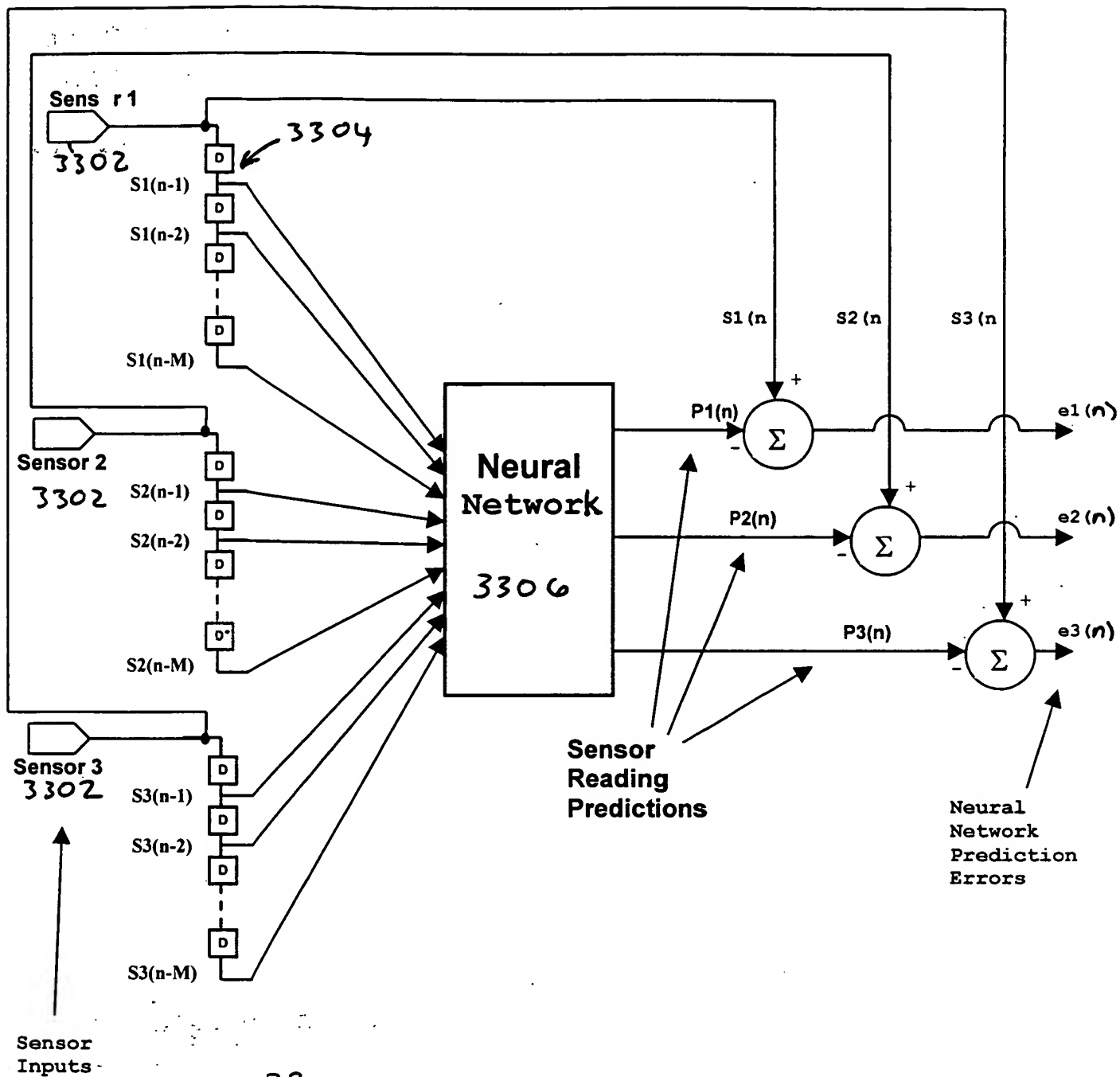


Figure 33 Adaptive Neural Network Predictor (ANNPA Method)

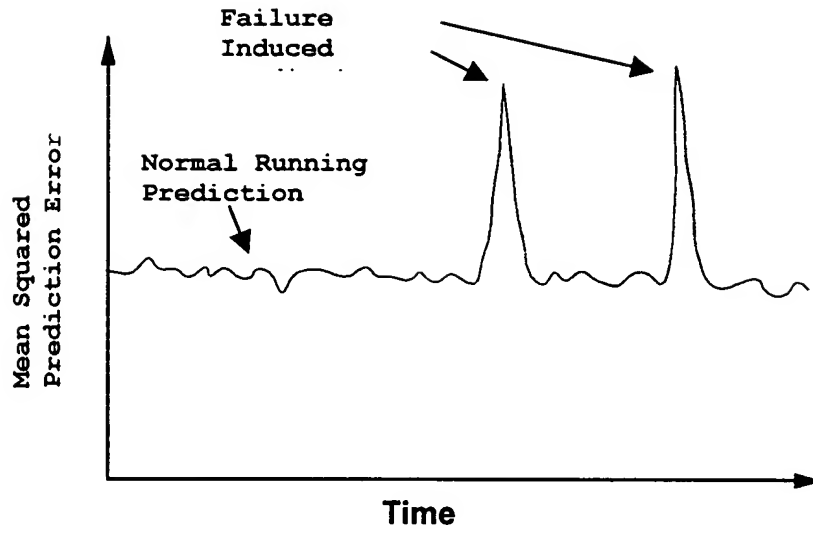


Figure 34 Failure Indications (ANNPA Method)

Acceleration (No Bearing Damage)

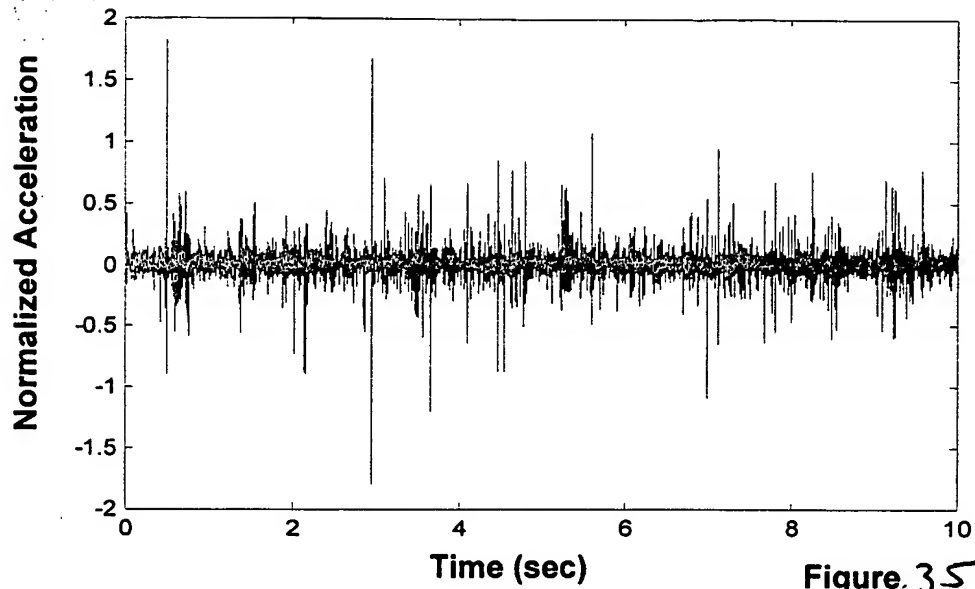


Figure 35

Acceleration Prediction Error (No Bearing Damage)

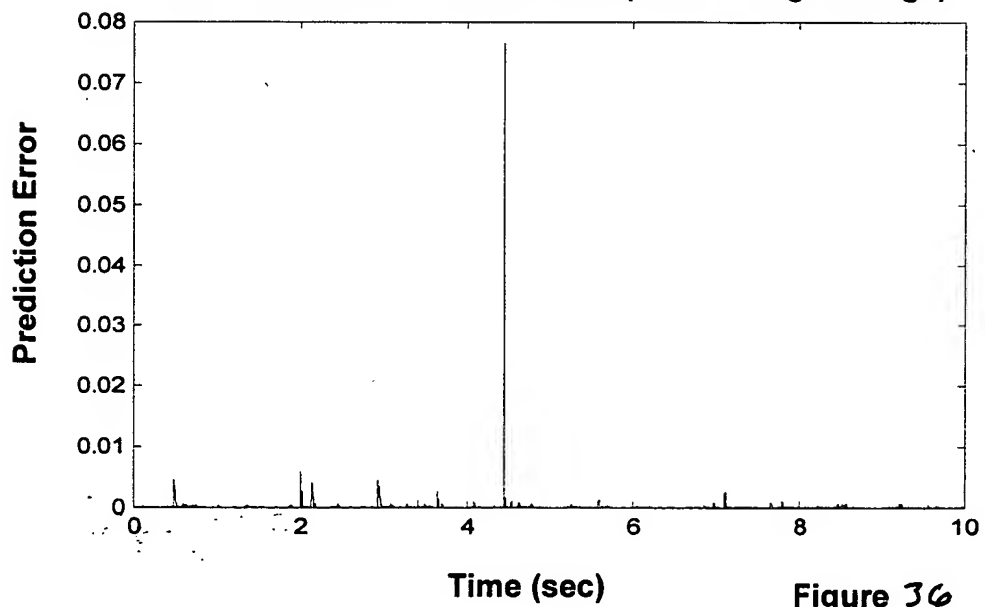


Figure 36



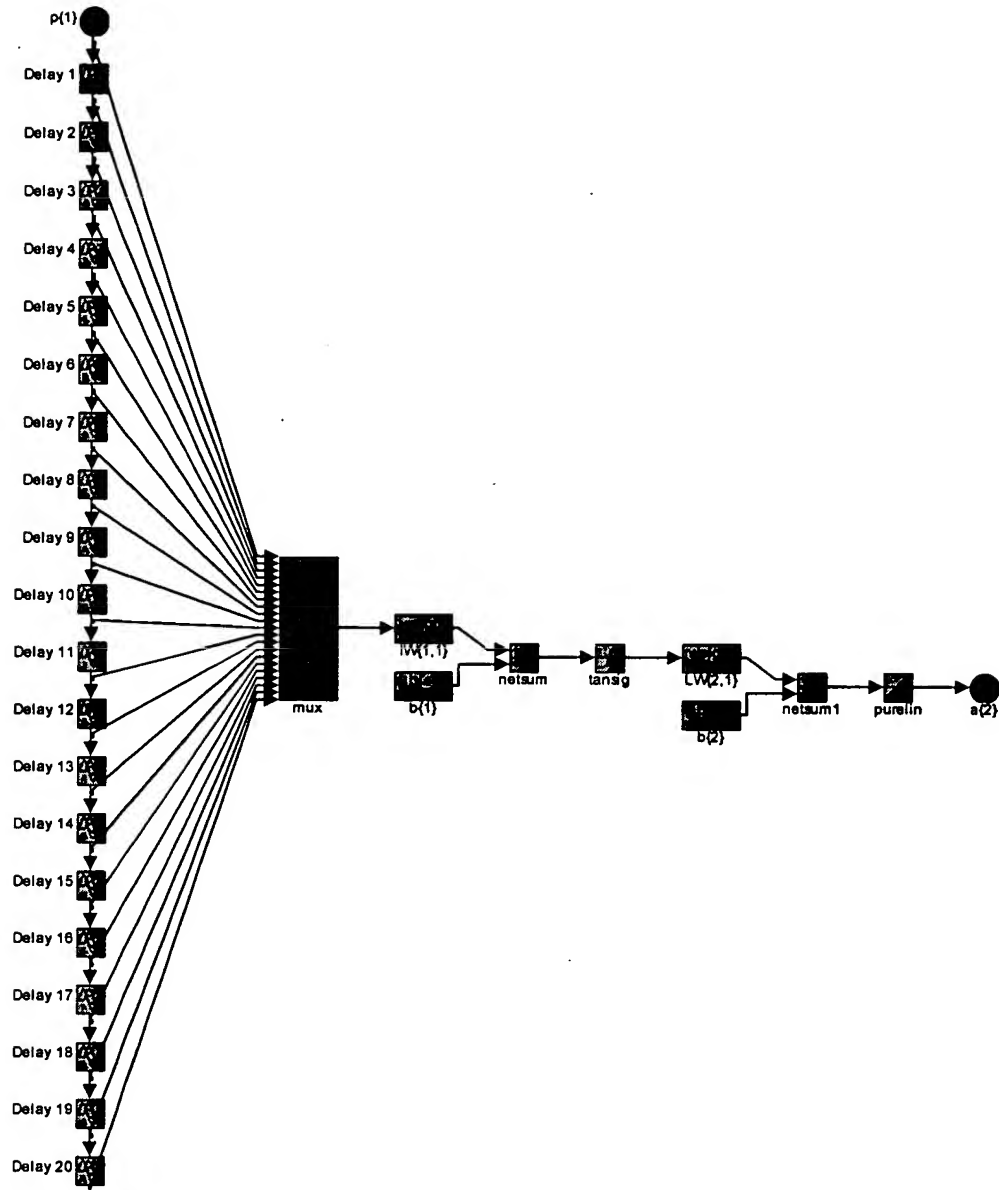


Figure 37

Acceleration (Light Bearing Damage)

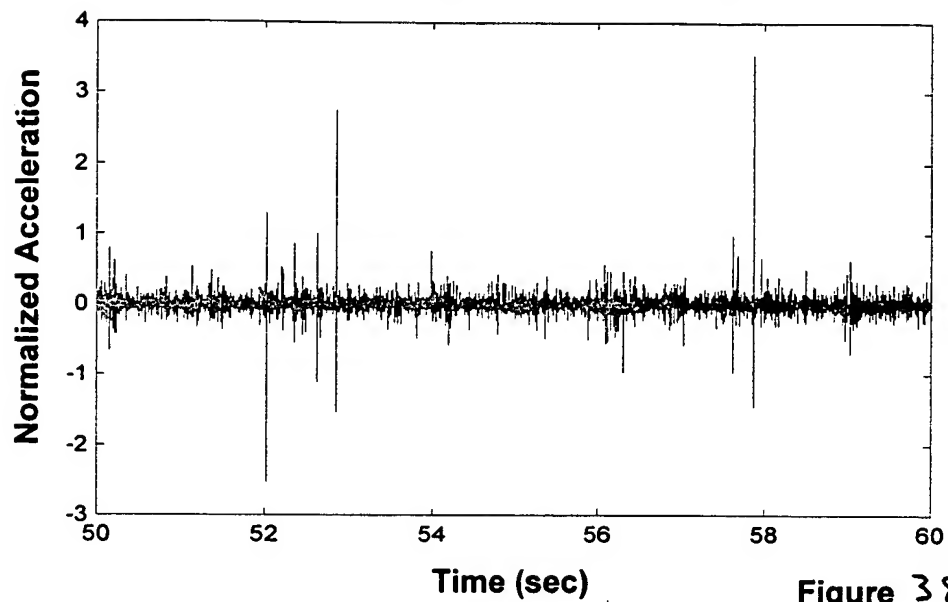


Figure 38

Acceleration Prediction Error (Light Bearing Damage)

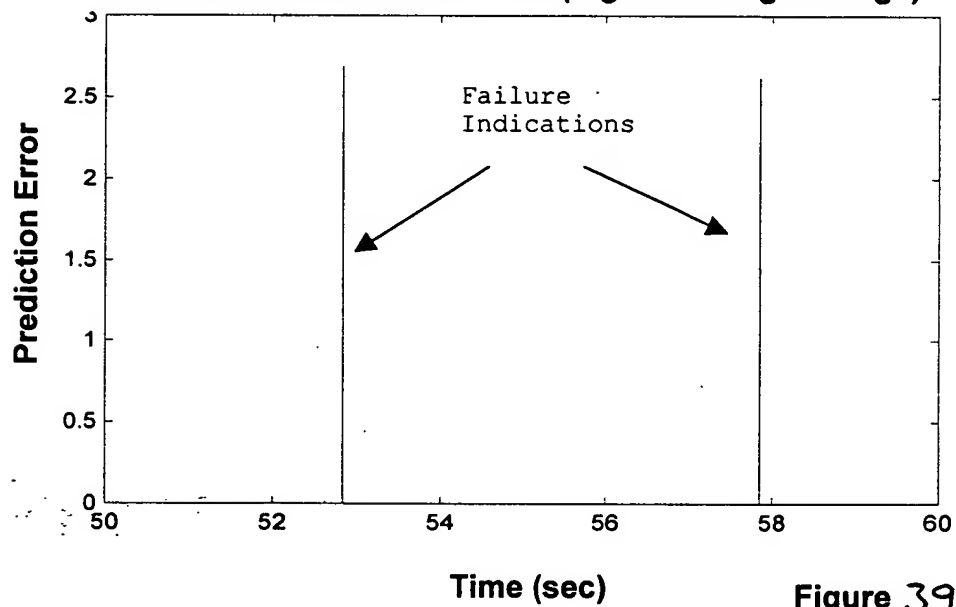


Figure 39

Acceleration (Moderate Bearing Damage)

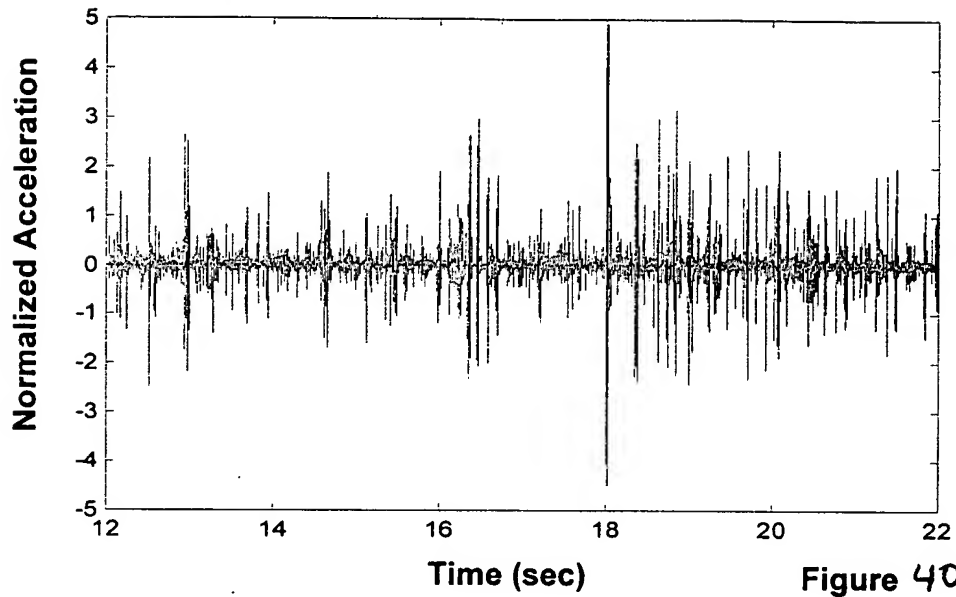


Figure 40

Acceleration Prediction Error (Moderate Bearing Damage)

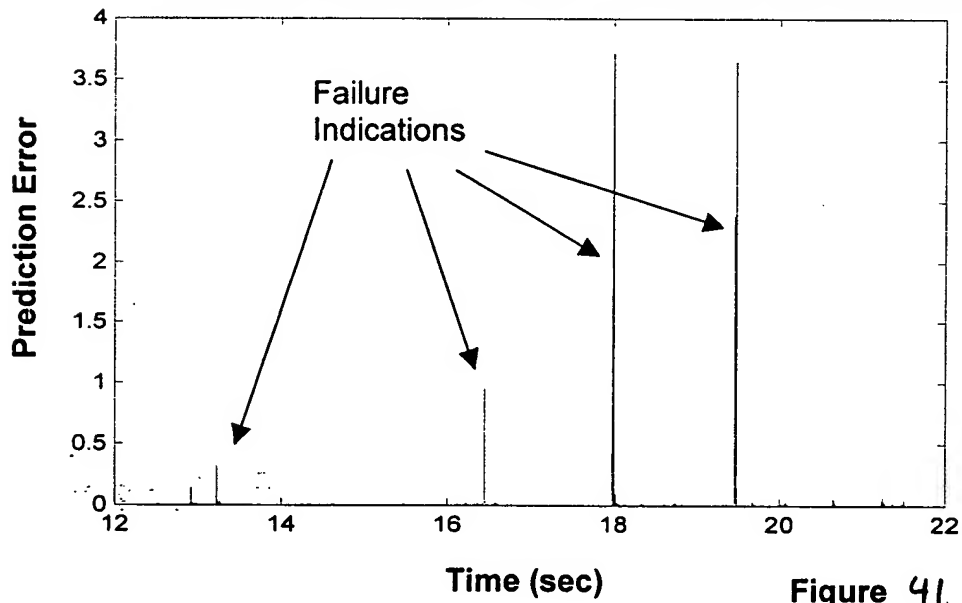


Figure 41

Acceleration (Heavy Bearing Damage )

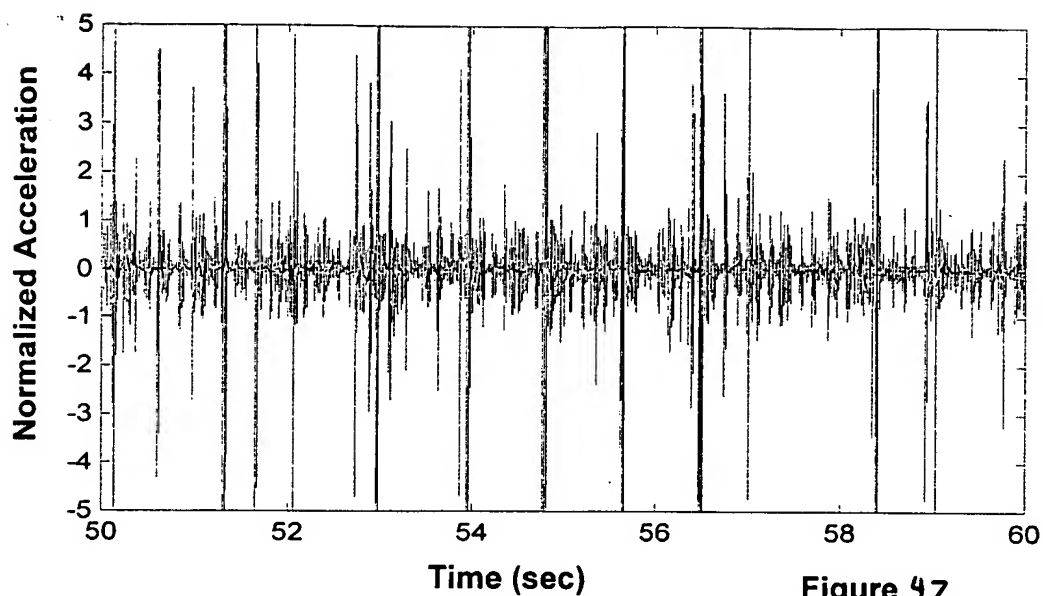


Figure 42

Acceleration Prediction Error (Heavy Bearing Damage)

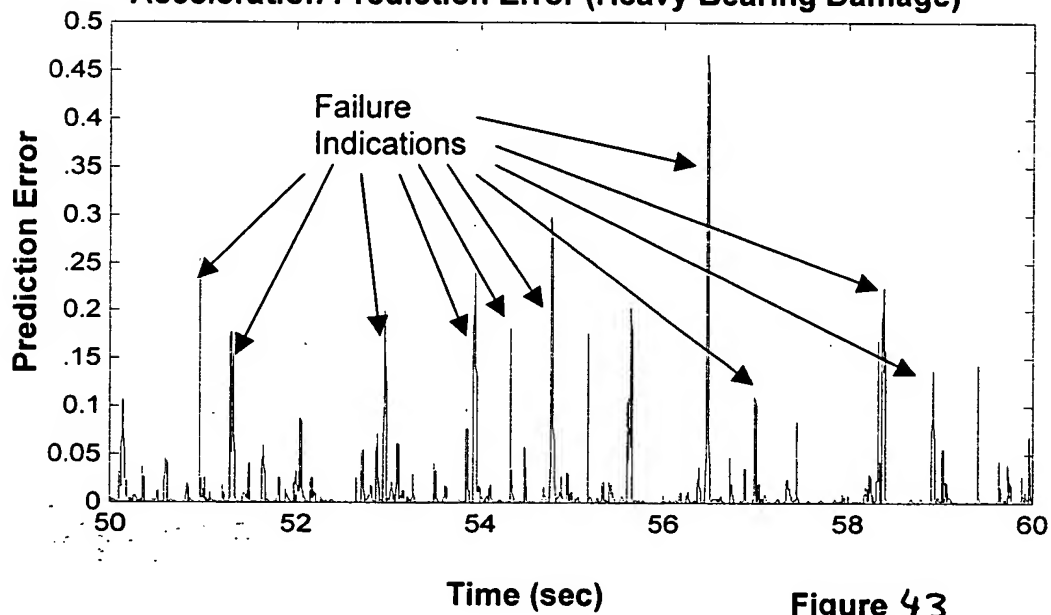


Figure 43

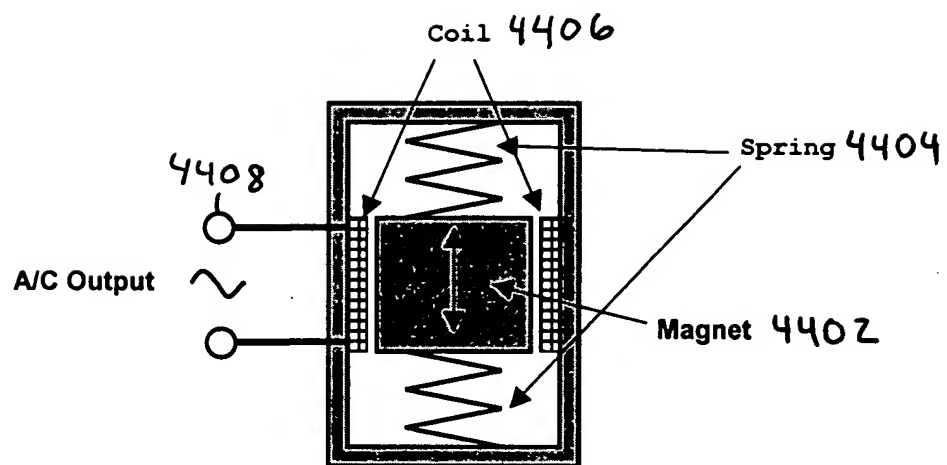


Figure 44 Diagram of Voice Coil Power Generator

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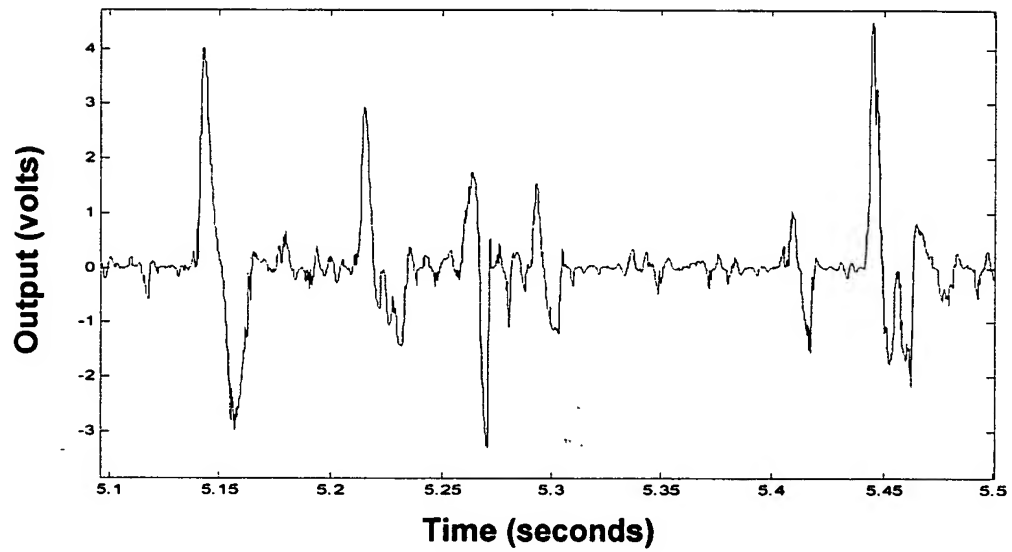
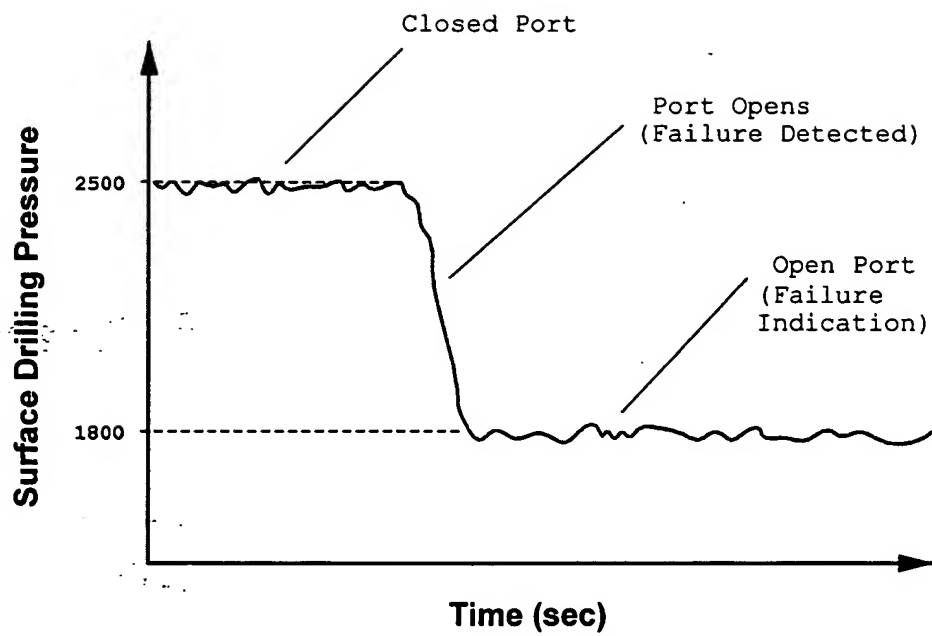


Figure 45 Scaled-Down Prototype Power Generator Output (1000  $\Omega$  Load)



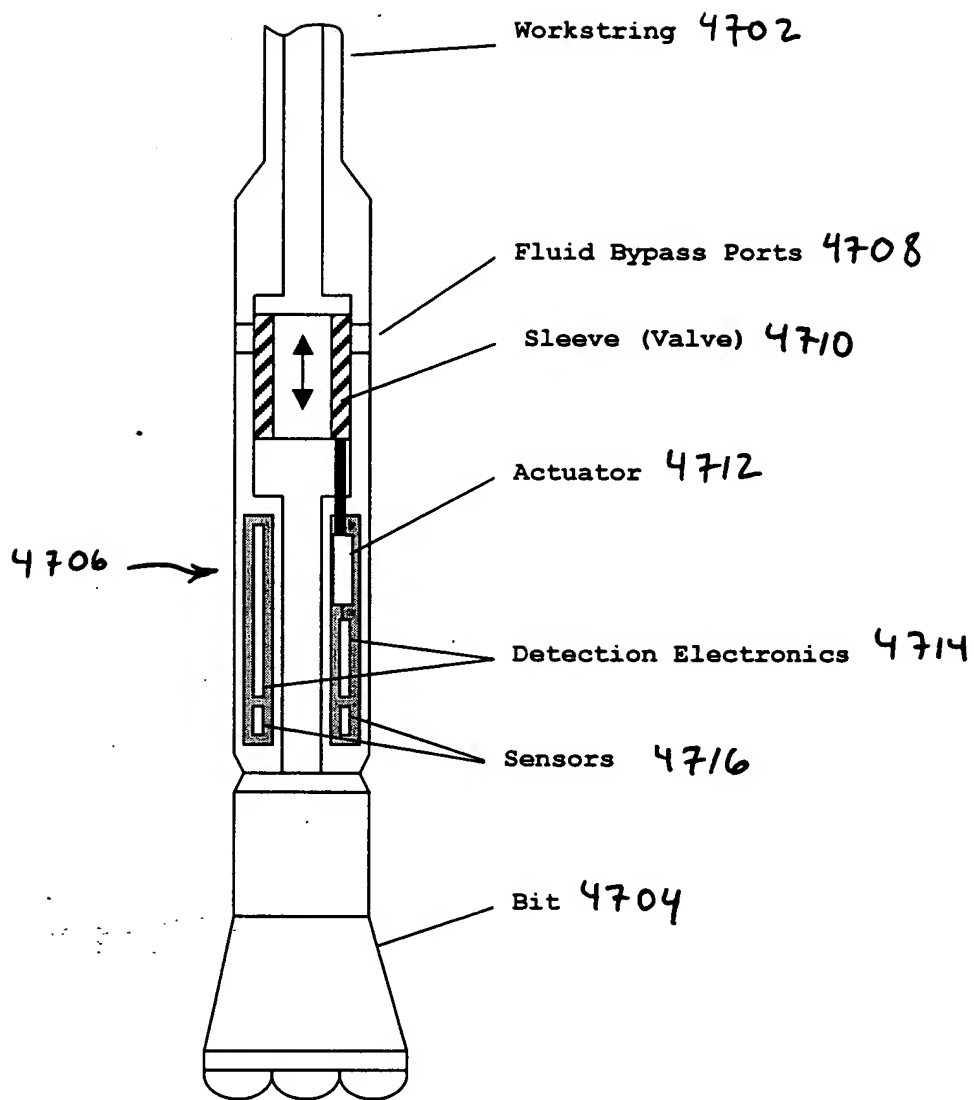


Figure 47 Downhole Tool Schematic



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T04T0T" S0T9E00T

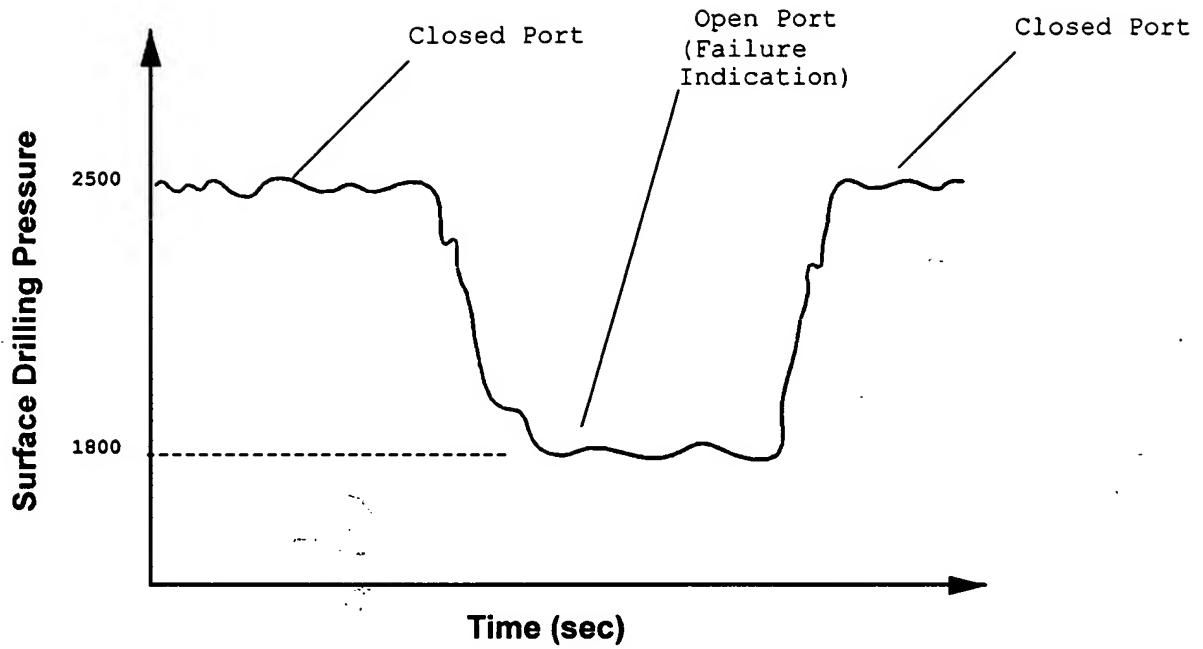


Figure 48 Open-Close Signaling Operation

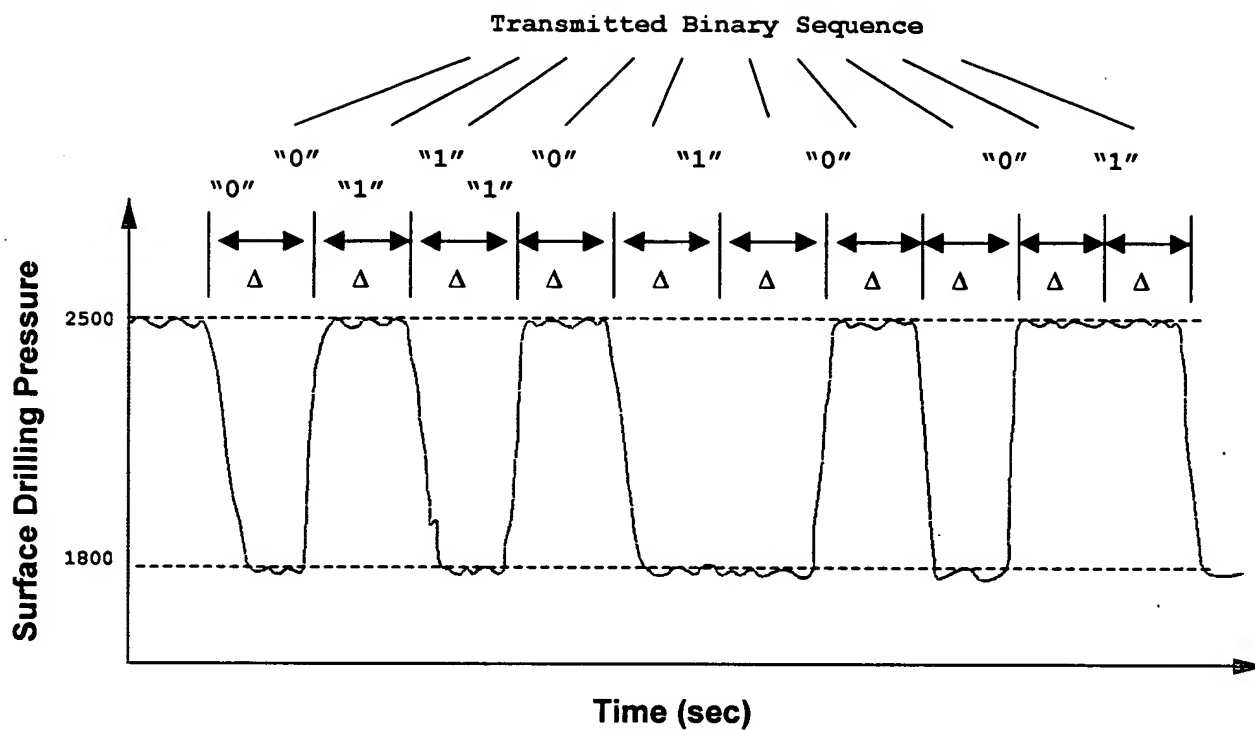


Figure 49 Binary Data Transmission Using Static Pump Pressure Lev Is

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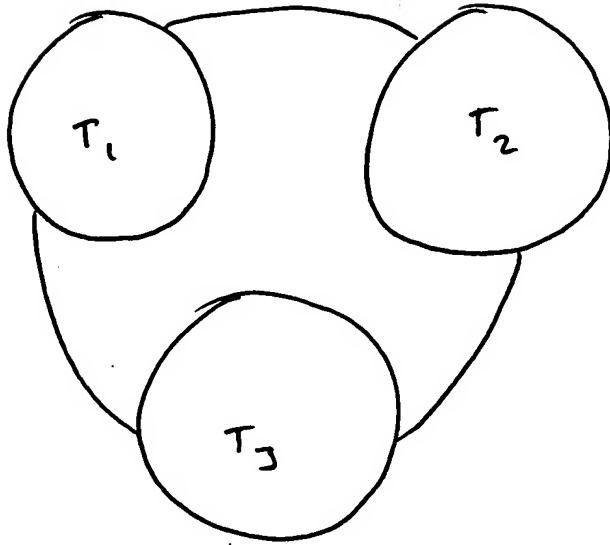


Figure 50

10036105-101701

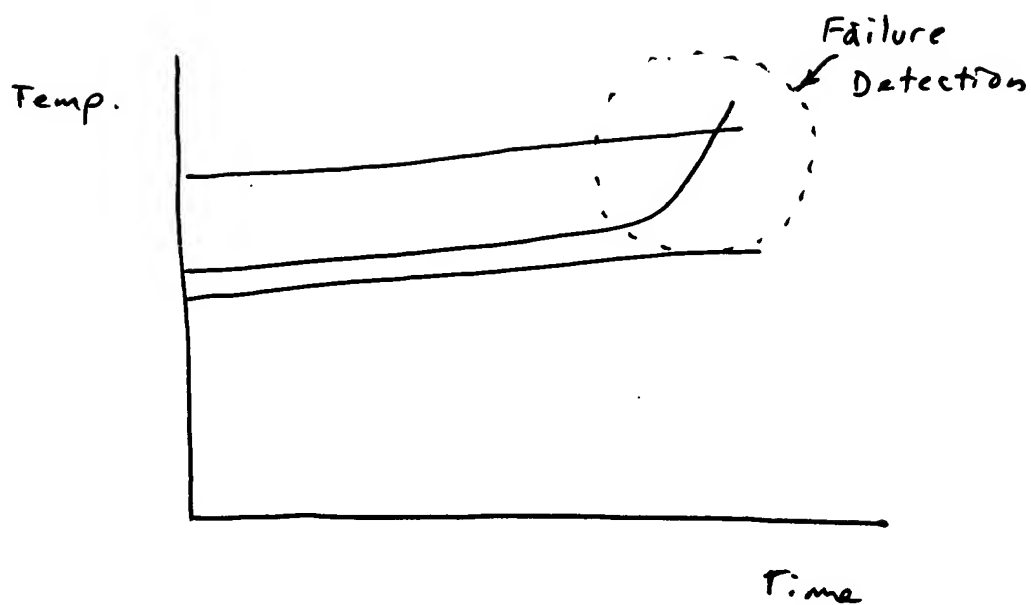


Figure 51

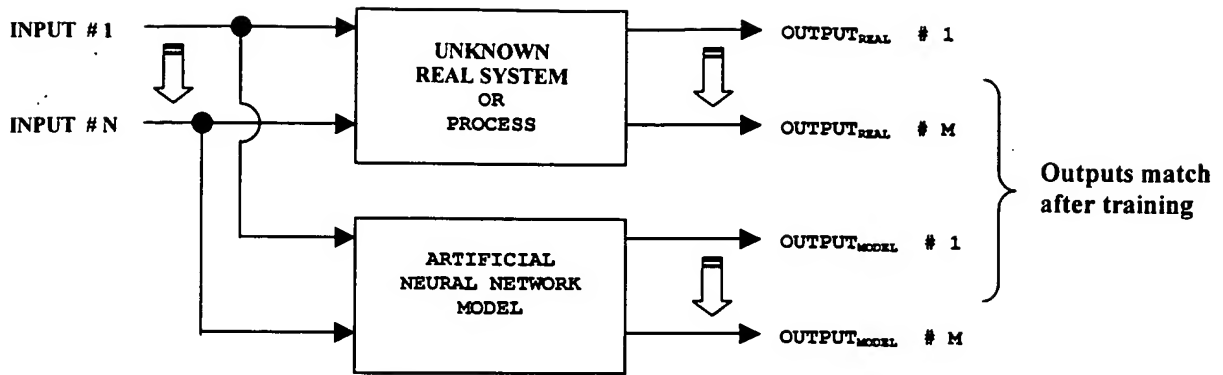


Figure 52 Neural Network Modeling  
Real System

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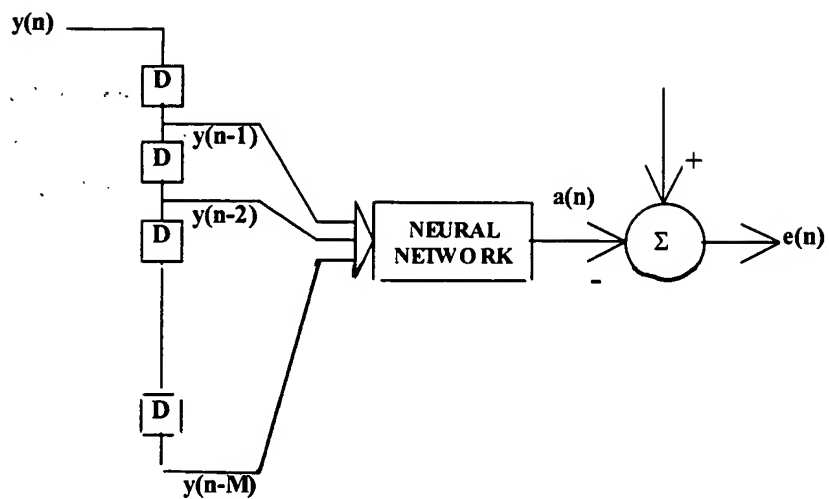


Figure 53

10036105-101701

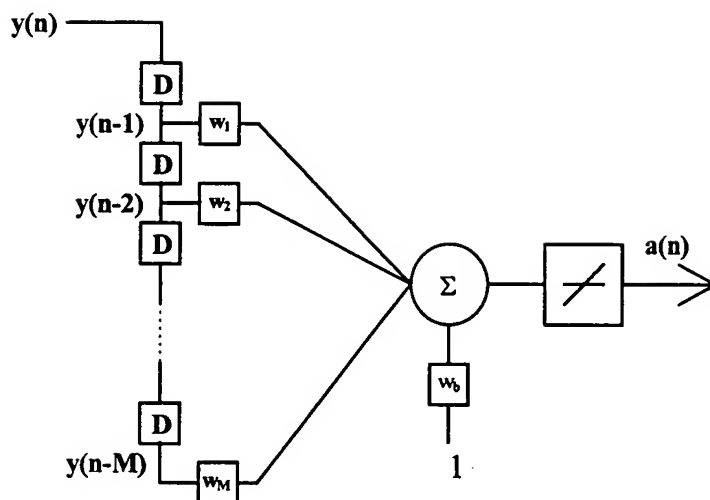


Figure 54 Basic Linear Network

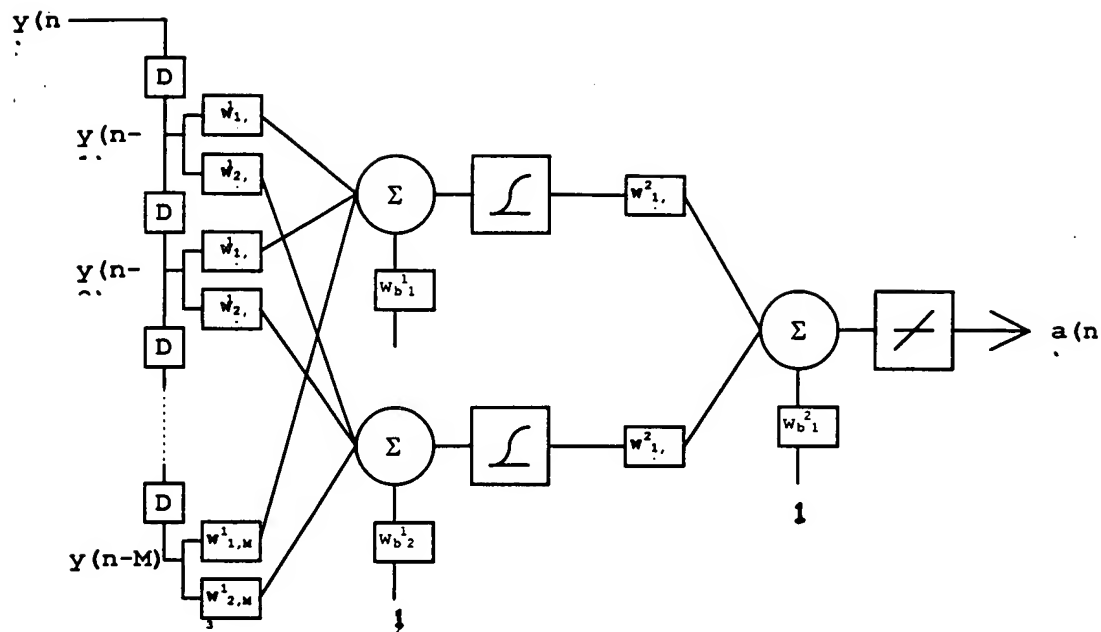


Figure 55



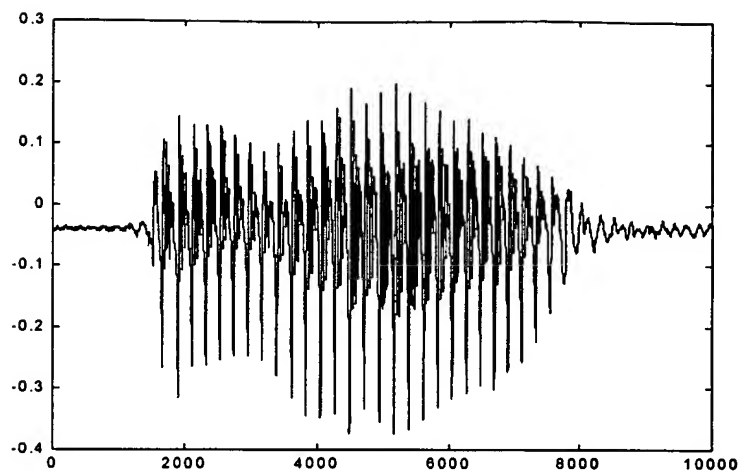
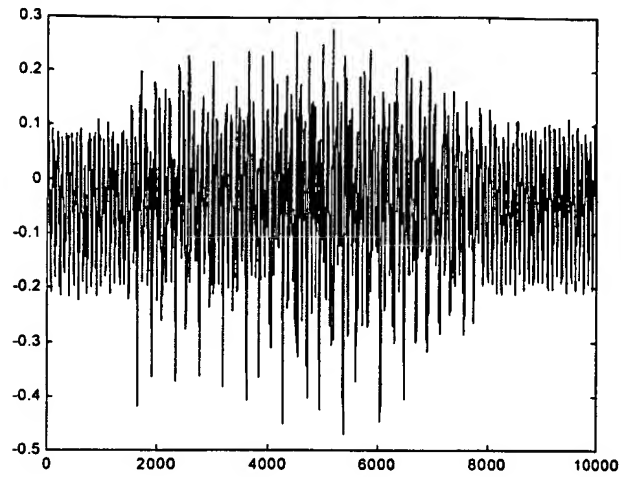
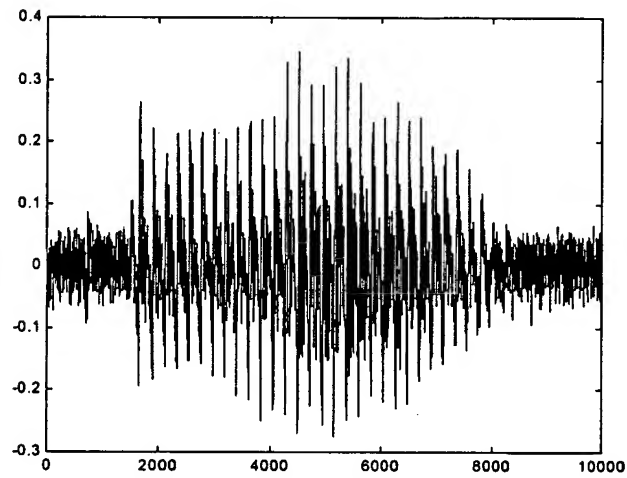


Figure 56

10036105-101701



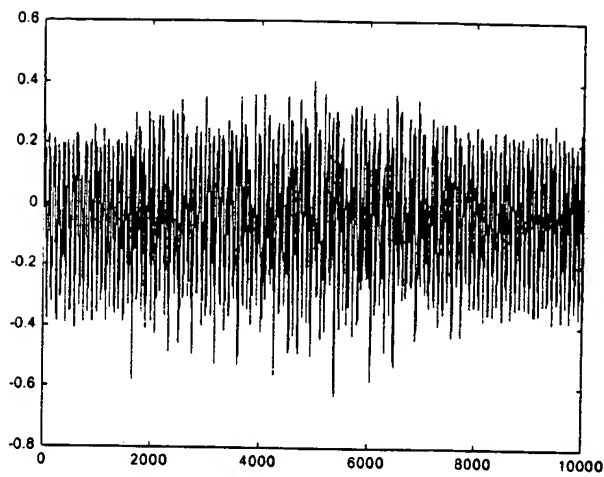
Corrupt Signal S/N Ratio = .95



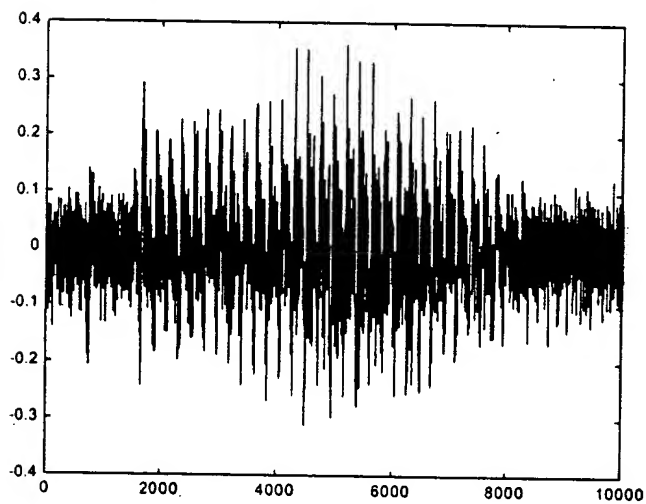
Filtered Signal S/N Ratio = 2.35

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Corrupt Signal S/N Ratio = .24

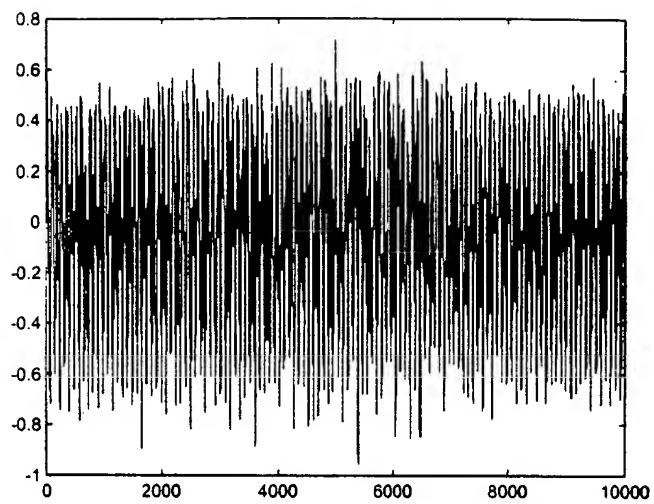


Filtered Signal S/N Ratio = 1.68

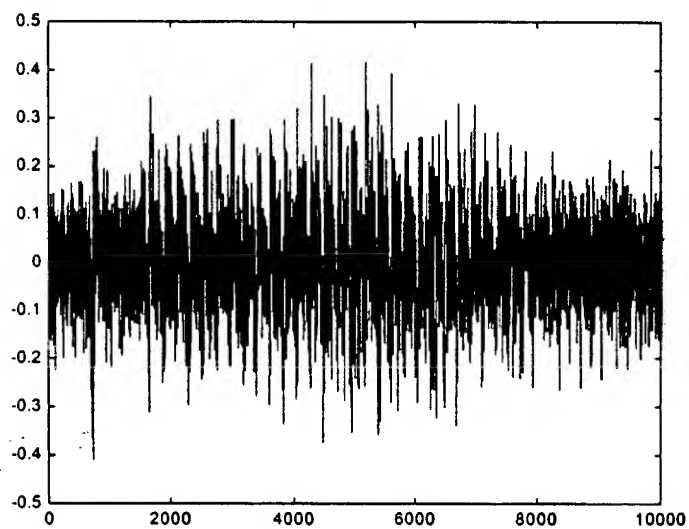
Figure 58

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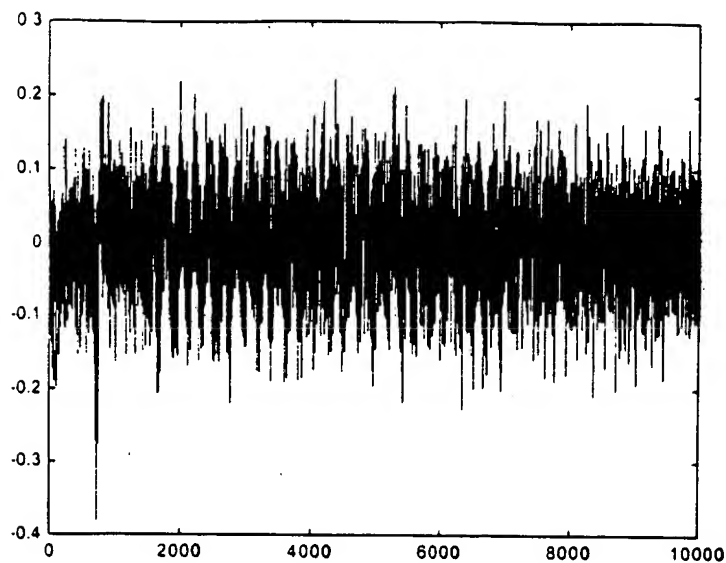
Corrupt Signal S/N Ratio = .06



Filtered Signal S/N Ratio = .89

Figure 59

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Linear filter results. S/N = .7457  
Figure 60